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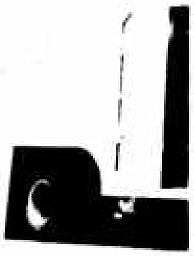

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TECHNICAL EVALUATION REPORTS OF AIRFIELD DAMAGE REPAIR SOLUTION

by

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APO New York 09034

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Final Report

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A specific goal of this series of six field tests by US Army Engineer troops was to test cold weather effects on selected repair techniques. The technical evaluations include small craters with regulated set concrete, small craters with high early strength concrete, small craters using grout and stone, large craters using crushed stone with sand blot, large craters using cold asphalt road mix, and spall repair using Silikal.

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18. SUBJECT TERMS (Continued).

Pavements--Maintenance and repair--Cold weather conditions (LC)
Concrete, Effect of temperature on. (LC)

PREFACE

The investigation reported herein was sponsored by the Office, Chief of Engineers (OCE), US Army Corps of Engineers, under Project AT40, Task CO, Work Unit 002, "Repair and Restoration of Paved Surfaces (REREPS)."

The work was conducted at the US Army Engineer Waterways Experiment Station (WES) from March 1979 through June 1979 by the Pavement Systems Division (PSD) of the Geotechnical Laboratory (GL) and the 293rd Engineer Battalion (Heavy), 18th Engineer Brigade. This report was prepared by LTC Jude W. P. Patin and CPT Robert Devens, 293rd Engineer Battalion, 18th Engineer Brigade, Europe, and Dr. George M. Hammitt II, PSD, GL, WES. This report was originally prepared as a Battalion Reference Document.

The work was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, GL, and COL J. Vanlobensels, Commander, 18th Engineer Brigade, and under the direct supervision of Mr. H. H. Ulery, Jr., Chief, PSD, GL.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

Appendixes B thru H which are illegible can be deleted.
Per Dr. George M. Hammitt, AEWES, Geotechnical Laboratory

CONTENTS

* Appendixes I-P are not included in this copy of the Technical Evaluation Report. If you require a copy of this information, it can be obtained from author.

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
degrees (angle)	0.01745329	radians
knots (international)	0.5144444	metres per second
miles (US statute)	1.609347	kilometres
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms
tons (2,000 pounds, mass)	907.1847	kilograms

TECHNICAL EVALUATION REPORTS OF AIRFIELD DAMAGE REPAIR SOLUTION

PART I: INTRODUCTION

Purpose

1. The purpose of this report is to provide documentation of airfield damage recovery (ADR) techniques used within the 18th Engineer Brigade in Europe (1979). This information can be used by the researcher and troop user alike to provide the repair of craters necessary to restore an airfield's horizontal construction to operational capability. The long-range purpose is to develop improved systems allowing a field commander to respond to various levels of hostility with a minimum of manpower, time, and cost. Current information within the state of the art of ADR can be used by units in the field for planning, estimating needed materials, organizing, and then accomplishing war damage repair missions to airfield pavements. The methods, materials, and techniques presented are those currently available for war-damaged airfield runways, taxiways, aprons, and roadways.

2. During the early periods of hostilities, the repair and restoration of airfield paved surfaces (REREPS) damaged by war are among the most significant engineer support missions. Lessons learned in Vietnam and the Israeli-Arab nation conflicts have illustrated the criticality of rapid ADR of specific air base facilities. The construction effort required will necessitate combined efforts of US forces and participation of host nations. The Army engineer forces have the following responsibilities: (a) providing repair/restoration of war damage to air bases beyond that of emergency repair, (b) assisting the Air Force in the emergency repair of war damage to air bases when that requirement exceeds the Air Force organic capability, (c) base development excluding the Air Force bed-down responsibilities, and (d) construction management of repair/restoration of war damage and base development. In addition to paved surfaces, the Army is also responsible for the acquisition, repair, improvement, expansion, and rehabilitation/construction of installations and facilities to support existing and deploying Air Force units. This support consists of rehabilitation/construction of such facilities as supply depots;

petroleum, oil, and lubricants (POL) systems; and buildings and roads conforming to theater of operations (TO) standards of construction.

Background

3. On 29 August 1940 in London, Prime Minister Churchill wrote to the Secretary of State for Air.

> All craters should be filled in within 24 hours at most, and every case where a crater is unfilled for a longer period should be reported to higher authorities. In order to secure this better service it will be necessary to form some crater-filling companies. These should be equipped with all helpful appliances and be highly mobile, so that in a few hours they can be at work on any site which has been cratered. Meanwhile, at every aerodrome there must be accumulated stocks of gravel, rubble and other appropriate materials.

4. The ADR is the primary wartime mission of the 18th Engineer Brigade in Europe. Conceptually, little has changed since Winston Churchill's words on airfield repair were written. The current NATO standard is to recover an airfield for emergency operations within 4 hr of an attack. Developing realistic methods and training to meet the standard is no small task in light of the airfield damage to be expected after an attack with modern weapons.

5. Training management of ADR is a true challenge. No Army doctrine for prescribed procedures is available for airfield recovery, and one of the most important goals of the training program in the 18th Brigade is to develop Army Training and Evaluation Program (ARTEP) task descriptions, standards, and goals. Draft ARTEP Training and Evaluation Outlines (TEO's) have been developed for each different technique for use in the Brigade's training program. Recently, combat realism has been incorporated into the runway repair exercises with some exercises conducted in full mission oriented protection posture (MOPP) gear, including protective masks. The operation of heavy equipment in a confined area under such conditions is a real command and control problem. Material procurement through host nation sources is expensive with unique staff coordination impacts. These areas represent only a few of the training management problems associated with a runway repair and ADR training program.

6. Within the 18th Engineer Brigade, the 293rd Engineer Battalion in

Baumholder, Germany, has been charged with the mission of developing rapid runway repair techniques of a semipermanent/permanent nature. The battalion has done this in conjunction with the US Army Engineer Waterways Experiment Station (WES) in Vicksburg, Mississippi. Working closely with the scientists and engineers of the WES since 1976, the 293rd Engineer Battalion has participated in field/operational testing of crater repair techniques. This testing by troops is being done on the training airfield at the Baumholder Training Area. This ongoing training has produced draft ARTEP TEO's; a field reference document, Airfield Damage Repair, published by the WES; draft technical reports on repair exercises; and doctrinal input from the 18th Brigade to the US Army Engineer School, Fort Belvoir, Virginia. Training on other aspects of ADR, such as repair of utilities and restoration of facilities, is accomplished by all 18th Engineer Brigade units through its troop construction in Europe. The other combat battalions in the 18th Brigade--the 79th in Karlsruhe, the 94th in Darmstadt, the 249th in Karlsruhe--and the Brigade's 6970th Civilian Labor Group also train in crater repair using the techniques developed.

7. Current evaluation efforts have examined the two major components of crater repair; crater bowl preparation and placement of a crater cap wearing surface. Techniques examined or currently being evaluated in this report are:

a. Regulated-set concrete.

b. BN 55, 25, 15 concretes.

c. AM2 airfield matting.

d. XM-19 airfield matting.

e. Full depth crushed stone aggregate.

f. Aggregate repair cap.

g. Aggregate/cement repair cap.

h. Asphalt.

i. Water-cement aggregate grout.

j. Reinforced earth.

k. Silikal®.

Sources of available aggregates for these techniques are given on a location map at the end of this report. Although these current techniques certainly do not represent the final solution for the crater repair problem, they do represent viable techniques within the 18th Engineer Brigade. The 18th Engineer Brigade will continue to set the pace for the Army in planning/developing ADR techniques for all phases of base recovery, to include the important area of crater repair.

Specific Purpose

8. The purpose of this field training was to evaluate four crater repair techniques and one spall repair technique. The field test was conducted during 1-10 February 1981 in order to test the various repair techniques during cold, inclement weather. The exercise was also to evaluate the impact the cold weather would have on the battalion's equipment and personnel during performance of the repair mission. Two of the crater repair techniques were new to the battalion and pretraining was required. The new techniques were the cold asphalt road mix repair and crushed rock and grout repair using the new concrete mobile mixer now organic to the battalion. While the battalion conducted the field test, it gained valuable training for its wartime mission.

Test Site

9. The battalion's test site was located in Baumholder, Germany, just east of Baumholder Army Airfield (see inclosure 1). It was a concrete slab 30 m wide by 120 m long. Ninety m of that length was 0.33 m thick, while the remaining 30 m was 0.15 m thick.

Construction of Craters/Spalls

10. The craters were constructed by dropping a 5,000-lb* iron ball on the concrete pad until the area required to produce the proper size crater was fractured. A D7 bulldozer utilizing both ripper assembly and front blade then dug out the crater to the required dimensions. The two dimensions of craters used during this operation were 6.0 m in diameter by 1.5 m deep and 20 m in diameter by 2.2 m deep. Ejecta was mounded around the edge of the crater simulating a bomb explosion. Upheaved sections of concrete were strewn throughout the ejecta (Photo 1). No cleanup of the area was performed. The spalls were made by the 80-lb jack hammer. Their dimensions were approximately 0.5 m in diameter and 0.2 m deep. Figure 1 illustrates the positions of the craters and spalls located at the test site.

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* A table of factors for converting non-SI units of measurement to SI (metric units) is presented on page 3.

Photo 1. Simulated crater

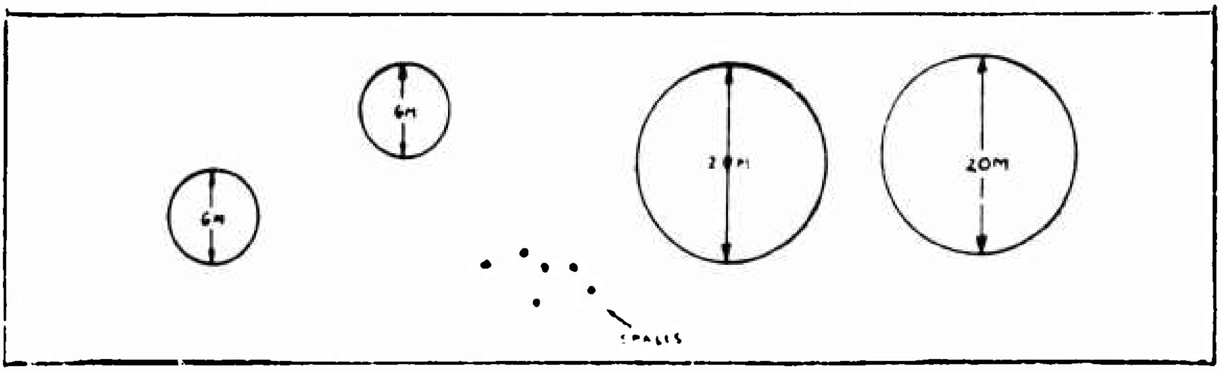


Figure 1. Illustration of craters and spalls

PART II: TEST CRITERIA

Test Vehicle

11. The apparatus used to test for the success or failure of the crater was a modified 5-ton bridge truck, 6x6, model M1-39. The truck was modified by removing the rear axle of the tandem and installing an Air Force F-4 aircraft landing assembly. Once in place, the load of the vehicle rested on the tire. The remaining rear axle acted as a stabilizing system to prevent vehicle turnover. Once the F-4 wheel was in place, the rear bed of the truck was loaded symmetrically with six reinforced concrete blocks (33 by 35 by 22 in.) to achieve a 27,000-lb (or better) load on the tire. Each block weighed 2261 lb. Six blocks were loaded on the vehicle. The rear axle load of the vehicle was 17,248 lb. The total weight on the tire was 30,816 lb. The tire pressure of the F-4 tire was 287 psi (Photos 2 and 3).

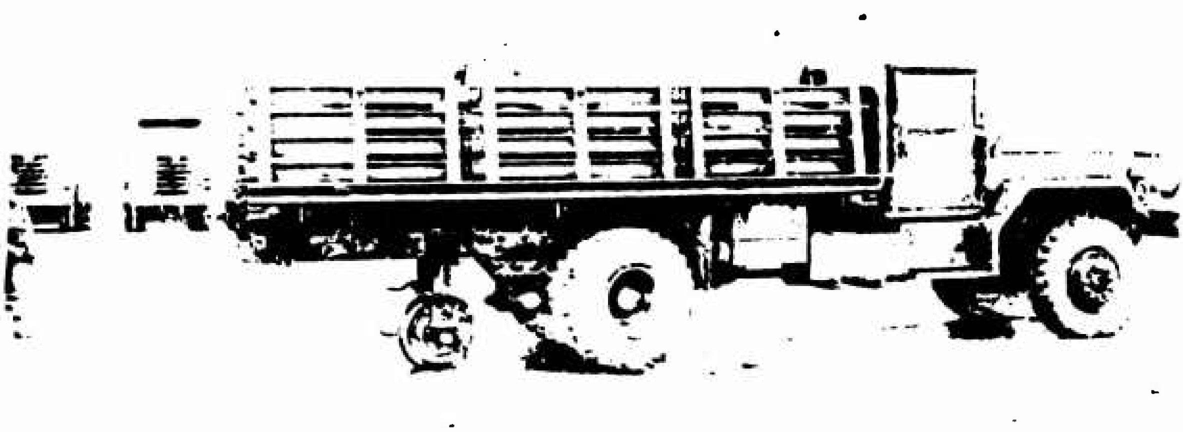


Photo 2. F-4 aircraft test vehicle

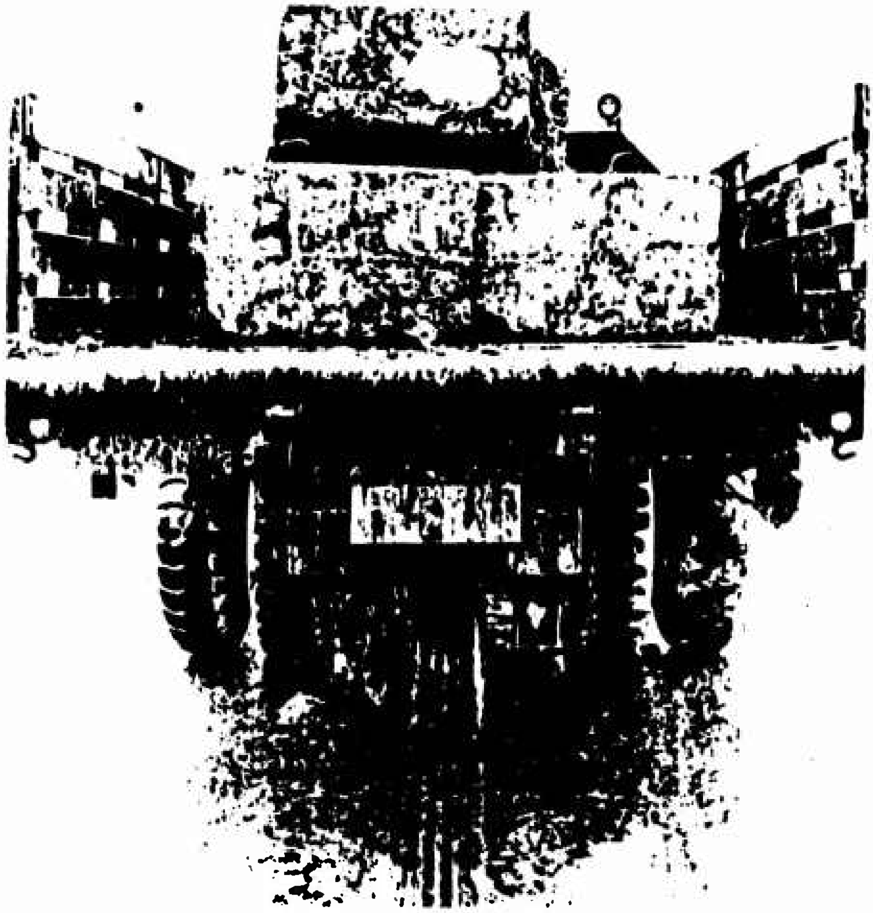
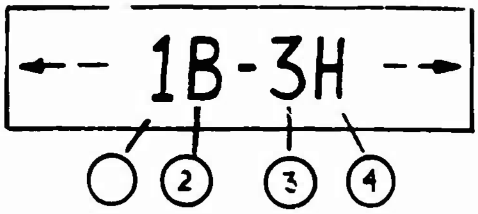


Photo 3. Rear view of test vehicle

Layout of Airfield

Test strip

12. The test site was described in Section 2, but for test purposes each crater was designated for evaluation. The large craters (20 m diameter) had three test strips each and the small craters (6 m diameter) two test strips each. Each test strip was designated by its crater and strip location, what company repaired the crater, and, if required, whether the crater was capped with High Early Strength concrete (H) or Regulated Set concrete (R). Each strip was 2 ft wide and the length of the crater. The strips were parallel to the direction that incoming aircraft would land. The strips were tested by running the F-4 vehicle over the strip 50 times or until the repair failed. Figures 2 and 3 describe the marking system for the strip.



(1.) The crater number (1 to 4). See Figure 3

(2.) The company that completed the crater (A or B).

(3.) The test strip number within the crater (1 to 3).

(4.) The type of capping material used (this is used for crater. Number 1 was used twice by each company for different concrete repair techniques, i.e., Regulated Set concrete (R) and High Early concrete (H)).

Figure 2. Identification data for test strips

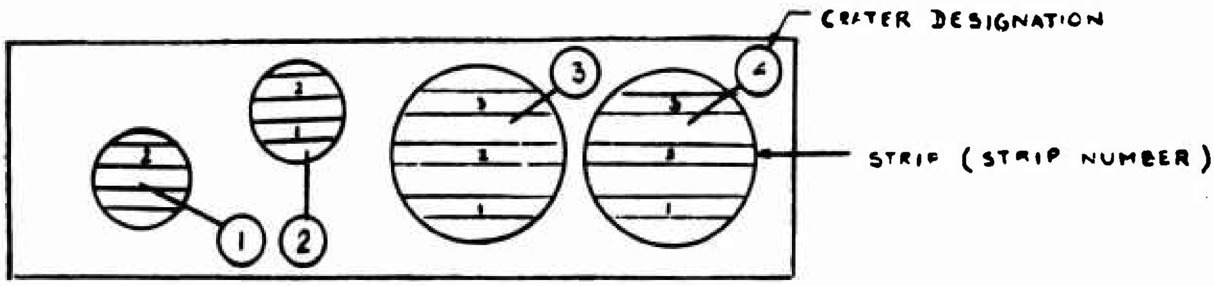


Figure 3. Crater and strip locations

Reports

13. During the operation, four personnel were on duty to report and record the required information. The temperature was monitored each day and the material tested, with the exception of the concrete compression strength test (eliminated due to a lack of cylinders). The compactive effort, density, and moisture content were monitored using a nuclear densitometer. The time sequence for each phase of the crater repair was recorded. Quality control was enforced and will be discussed later during the results of each crater technique.

Photographic coverage

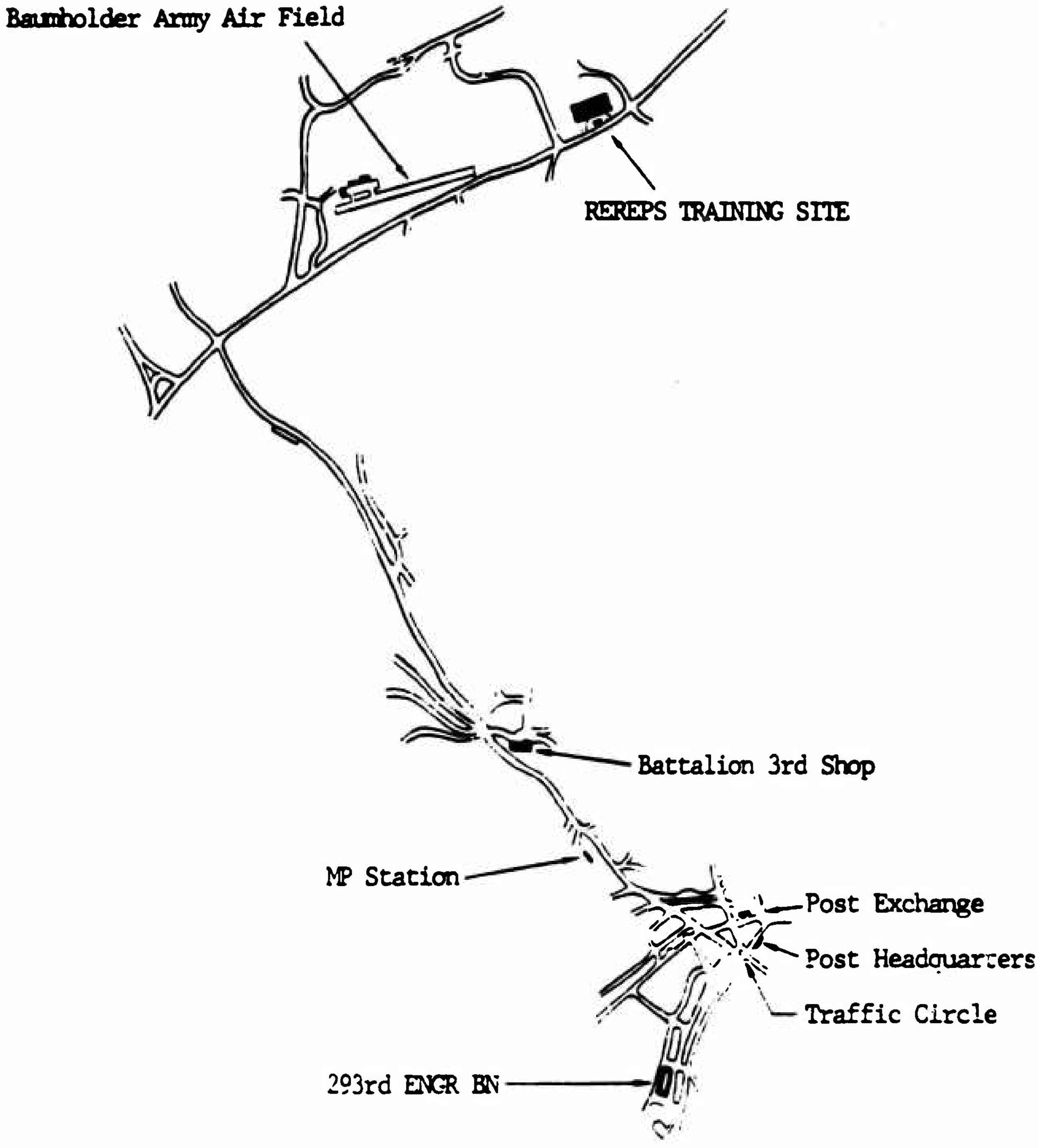
14. Photographs were taken to document the results for later analysis if required.

Analysis

15. The analysis of the operation was based strictly on individual craters. The F-4 test vehicle was the test criteria for success or failure. An analysis will follow each crater's report.

Recommendations

16. After each crater has been analyzed, recommendations for new techniques will be discussed on the basis of the results and/or the procedure used.



STRIP MAP TO REREPS TRAINING SITE

Inclosure 1

APPENDIX A: TECHNICAL EVALUATION REPORTS

Technical Report 81-2-1

Field Test of Small Crater Repair Utilizing Regulated Set Concrete

Prepared by

CPT Robert M. Devens

Headquarters, 293d Engineer Combat Battalion (HV)

18th Engineer Brigade

APO New York 0903-

30 April 1981

CONTENTS

I. **Materials**

a. Concrete, B35, ready mixed, consisting of the following material, proportioned on the basis of one (1) cubic meter (cz):

(1) Portland cement 450F, modified, type HEIDELBERGER SCHNEUZEMENT	430 KG
(2) Sand 0-2 mm DIN 4226, sh 1	560 KG
(3) Aggregate 2-8 mm DIN 4226, sh 1	380 KG
(4) Aggregate 8-16 mm DIN 4226, sh 1	580 KG
(5) Aggregate 16-32 mm DIN 4226, sh 1	130 KG

(DIN 4226 is attached as Appendix K).

b. Addiments:

(1) ADDIMENT SCHNELLZEMENT VERZOEGERER (retarder) liquid, quantity 0.35 percent of the cement weight. (See Appendix N for more information.)

NOTE: All the above materials were purchased from:

NAHE-BETON

LIEFERBETON NAHE GMBH

6580 Idar-Oberstein - Bahnofstrasse 23

c. STONE, crushed, aggregate, for road base construction, hardstone, premixed, material and mixture in accordance with "Technical Specifications and Directives for Construction of Road Bases Underwearing Courses (TVT)", grain size 0-32 mm. (NSN: 5610-00-V81-0643) See Appendix H for sieve analysis data. The stone was purchased from:

HORST KORB, Am Bahnhof 15

6589 Ruschberg, Rheinland-Pfalz

II. Technique/Procedure: See Appendix A for the Technical Evaluation Outline (TEO).

III. A Co Operation

a. Construction Sequence

1210 - Advance Party Arrived

1210 - Security Set Up

1245 - Cleared Area

1253 - Main Body Arrived

1254 - Began Clearance of Debris from Crater

1315 - First Truck Arrived with Aggregate

1317 - Began Filling Crater

1328 - Compacted Debris

1347 - Cleared Edge

1400 - Began Filling First Lift

1403 - Finished Compaction

1414 - Cleaned Edge

1430 - Began Filling Second Lift

1500 - Finished Compaction

1510 - First Concrete Truck Arrived

1513 - Second Concrete Truck Arrived

1522 - Recompacted Second Lift

1542 - Third Concrete Truck Arrived

1552 - Began Placement of Concrete

1702 - Completed Floating Concrete (Photo A1)

b. Problems Encountered

(1) Sweeper was inoperable.

(2) No one spotted for the unloading of the aggregate.

(3) Time for concrete trucks to mix caused delay.

(4) Another 5-cu yd loader was needed.

(5) The water truck ran out of water when priming concrete readimix trucks at 1630 hr causing a 40-min delay.

(6) Sweeper and dryer arrived before advance party.

c. Weather Conditions: 2 February 1981

Wind Direction - 222 deg

Wind Speed - 2 knots (no gusts)

Visibility - 7 miles (unlimited)

Sky Condition - Clear (no ceiling)

Temperature - 7°C (no wind chill factor)

d. Results:

LIFT INFORMATION

	Debris	1st Lift	2nd Lift
d	125	137.5	130
% W	12	12	12
% Compaction	88	96	92

Reading time/Test - 1 or 2 min   Testing depth - 6 in.

Remarks: The debris was compacted by a 5-cu yd front loader. The required compaction effort was $\geq$85% CE 55. The other lifts were compacted using a 30-ton vibrator roller and to a compaction effort of $\geq$95% CE 55. The samples were taken in the middle third of the crater. The results of the concrete's flexural strength are in Inclosure 1 of this test package. The

quality of the crater was excellent. The construction followed the technical evaluation outline (Appendix B).

The crater was tested 17 hr after its completion. No special method of curing was employed, the cap was completely exposed to the environment. The test sample was cured under the same conditions.

Test strip 1A-1R (Figures A1 and A3) completed 50 passes. A depression formed at each end of the test strip where the new cap met the existing surface. The concrete became a soupy mixture and had little aggregate within it. The depression stopped where aggregate was located. Along the path of the test vehicle's tire, a slurr of about 1/8-3/16 in. depth formed. This slurr was caused by frost action over the night, therefore curing did not take place. A high moisture content was found in the top 3/16-in. layer. No deflections or cracks were observed. Figure A2 shows the actual construction of the crater.

Test strip 1A-2R (Figures A1 and A4) completed 50 passes. Along the path of the test vehicle's tire, a slurr of about 1/8 in. deep formed. This slurr was caused by the frost action over the night and curing did not occur. The top 1/8 in. also had a high water content when the concrete was floated. No deflections or cracks were observed.

e. Analysis: If the crater was given more time to cure during hours of freezing temperature, the depressions would not have occurred. This is also true for the slurr caused by the friction between the crater surface and test vehicle's tire.

The subgrade was only 3% off the required compaction effort. This did not affect the crater for no deflections were observed. No cracks were observed.

III. B Co Operation

a. Schedule of Events

1040 - Advance Party Arrived

1041 - Security Set Up

1051 - Began Clearance of Area

1111 - Completed Clearance of Area

1117 - Main Body Arrived

1130 - Began Pumping Water from Crater with Compressor (Photo A2)

1130 - Two Trucks with Aggregate Arrived

1142 - Began Stock Piling Aggregate

1155 - Began Clearing Larger Debris from Crater

1210 - Another Truck with Rock Arrived

1212 - Another Truck with Rock Arrived

1246 - Two more Trucks with Rock Arrived

1250 - Began Clearing Edge of Crater

1252 - Began Filling Crater with 75-125 mm Aggregate

1325 - Completed Fill to 36 in. Below Surface

1326 - Two Trucks with Rock Arrived

1335 - Began Compaction of Edge

1345 - Began Compaction of Debris with 5-cu yd Front Loader

1349 - Compaction Test

1356 - Began Filling First Lift

1409 - Compacted Final Lift

1413 - Compaction Test (Photo A3)

1416 - Cleared Crater Edge

1425 - Began Filling Final Lift

1432 - Compacted and Cleaned Edge

1456 - Compacted Final Lift

1457 - First Concrete Truck Arrived (6 cu yd)

1501 - Final Compaction Test

1520 - Began Sweeping Area

1535 - Second Concrete Truck Arrived

1538 - Began Mixing Concrete

1550 - Began Placing Concrete

1610 - Began Screeding Concrete (Photo A4)

1700 - Began Floating Concrete

1725 - Crater Repair Complete

b. Problems Encountered

(1) The 5-cu yd loader became stuck in the center (15 min were lost). When removed, the cab to the front loader was dislodged and was out of action until 1320 hr.

(2) Because of the moisture content and standing water, large aggregate (75-125 mm) was added to the debris to stabilize the wet material.

(3) The motorized sweeper was inoperable.

(4) No one spotted for the dump trucks.

(5) The proper floating tools were not on site in quantity or type.

(6) The concrete forming and finishing crew was not organized.

c. Weather Conditions: 9 February 1981

Wind Direction - 170 deg (variable)

Wind Speed - 3 knots

Visibility - Unlimited

Sky Condition - 3,500 ft

Temperature - 4°C (low)/8°C (high)

d. Results

LIFT INFORMATION

Test	Debris	1st Lift	2nd Lift
d	85.3	85.3	92.8
% W	18	18	18
% Compaction	68	68	73

Reading Time/Test - 1 or 2 min   Testing Depth - 6 in.

Remarks: The debris was compacted with a 5-cu yd front loader. The required compaction effort was ≥85% CE 55. The other lifts were compacted using a 30-ton vibratory roller and had a requirement of ≥95% CE 55. The samples were taken near the center of the crater. The results of the concrete flexural strength test are contained in Inclosure 3 of the test package. The quality of the crater's construction was not done to the specifications in the Technical Evaluation Outline (Appendix B). The crater did not meet the compaction effort specified on all lifts. The debris reached only 68%, not the required ≥85%. The crater had 26 in. of standing water at its deepest point in the crater. Large aggregate (75-125 mm) was used in an attempt to increase the compactability of the debris. The first lift reached only 68%, not the 95% requirement. The second lift reached only 73%, not the 95% requirement.

The crater was tested 17-1/2 hr after its completion. No special method of curing was employed. The cap was completely exposed to the environment. The results of the concrete's flexual strength are in inclosure 2 of this test package. The test sample was cured under the same conditions.

Test strip 1B-1R (Figures A5 and A7) completed 50 passes. No deflections or cracks were observed. The strip showed no signs of being affected by the frost. Figure A6 shows the actual construction of the crater.

Test strip 1B-2R (Figures A5 and A8) completed 50 passes. No deflections or cracks were observed. The strip showed no signs of being affected by the frost. At one edge where the strip meets the existing pavement, there was an uneven lip. Under the weight of the test vehicle, this lip collapsed.

e. Analysis: The concrete cap had no deficiencies except for that of the lip. The moisture content of the debris and aggregate was 18% which caused the poor compaction effort. The subgrade did not affect the results of the test. The crater had 26 in. of standing water prior to the repair. Large aggregate (75-125 mm) was found to be very useful in achieving a 68% CE 55 whereas the compaction would have been very low using water saturated debris only. Vehicles would have been entrapped if nothing was used.

V. Recommendations:

a. During very cold or very hot conditions, proper curing methods need to be added to the TEO (Appendix B). The use of a plastic film (10 mil polyethylene) or straw would have produced better curing results.

b. The crater constructed by B Company held up to the test despite poor compaction. In order to save time, the compactive efforts of each lift to include the debris could be decreased by 10 to 15 percent.

c. The crater constructed by B Company had 26 in. of standing water. The use of the large (75-125 mm) aggregate helped to achieve a higher compactive effort. This would not have been achieved if only the water saturated debris was used. This procedure should be written in the TEO (appendix A) as a contingent method if inclement weather should occur. This process would save time and effort since the compactive effort required can be reached quicker and the possibility of an entrapped vehicle is reduced.

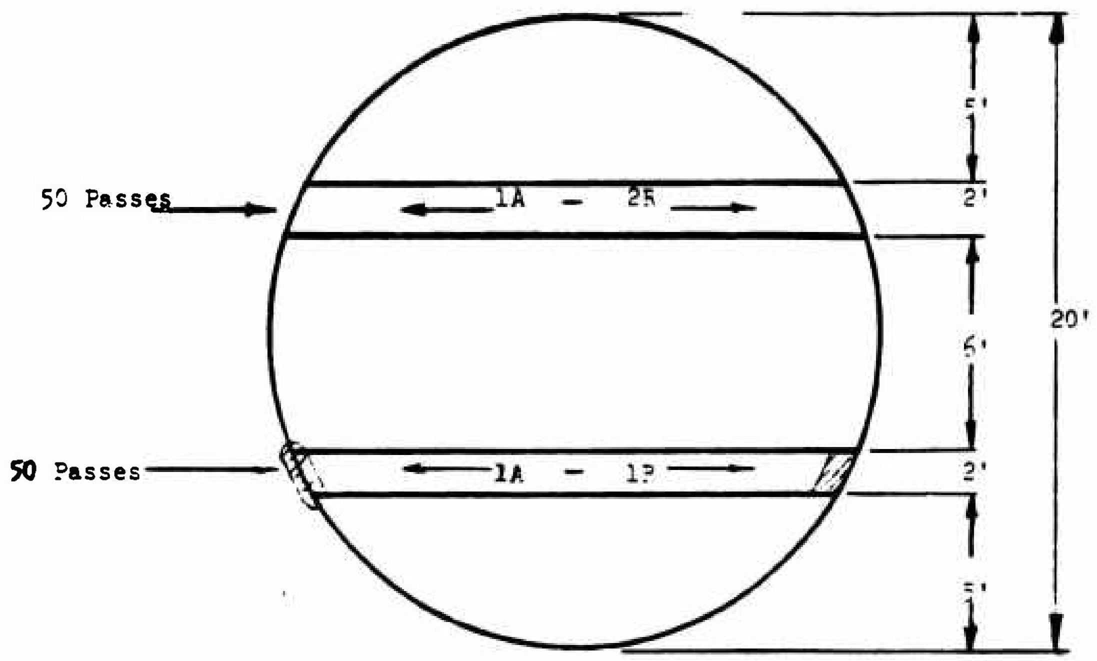


Figure A1. Top view of crater after test

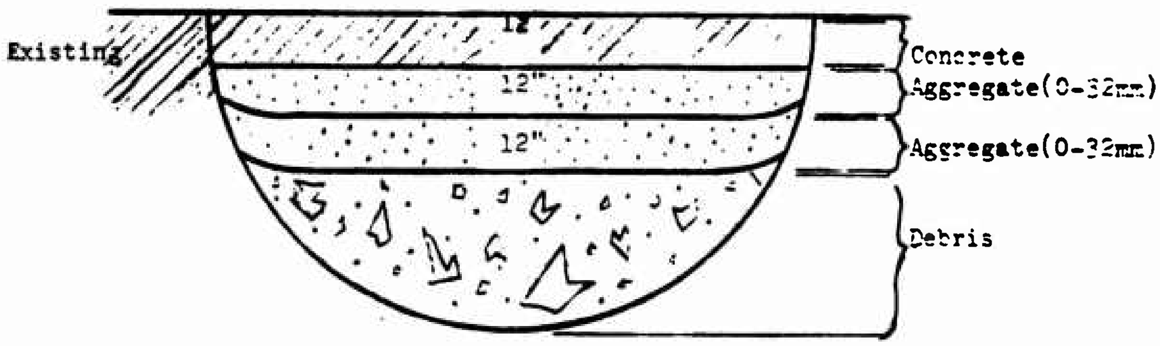


Figure A2. Actual construction of crater

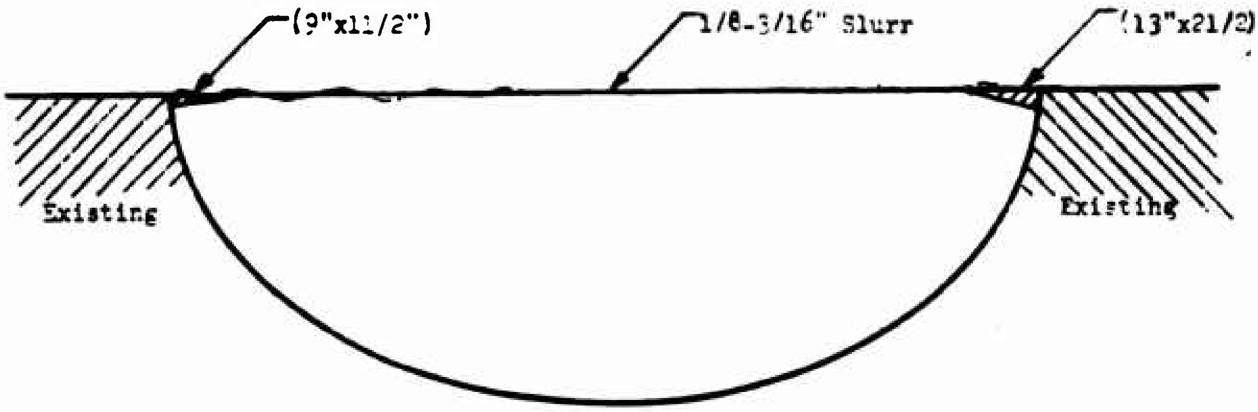


Figure A3. Side view of test strip 1A-1R

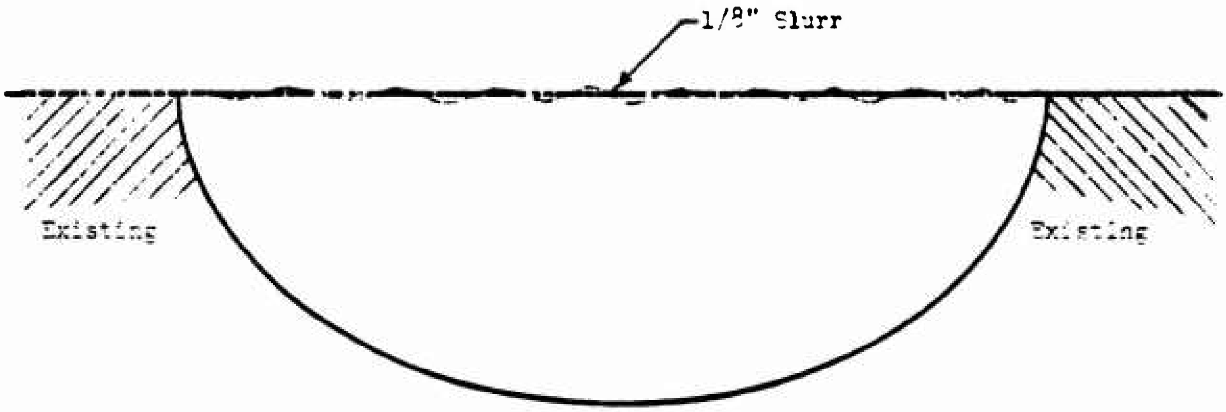


Figure A4. Side view of test strip 1A-2R

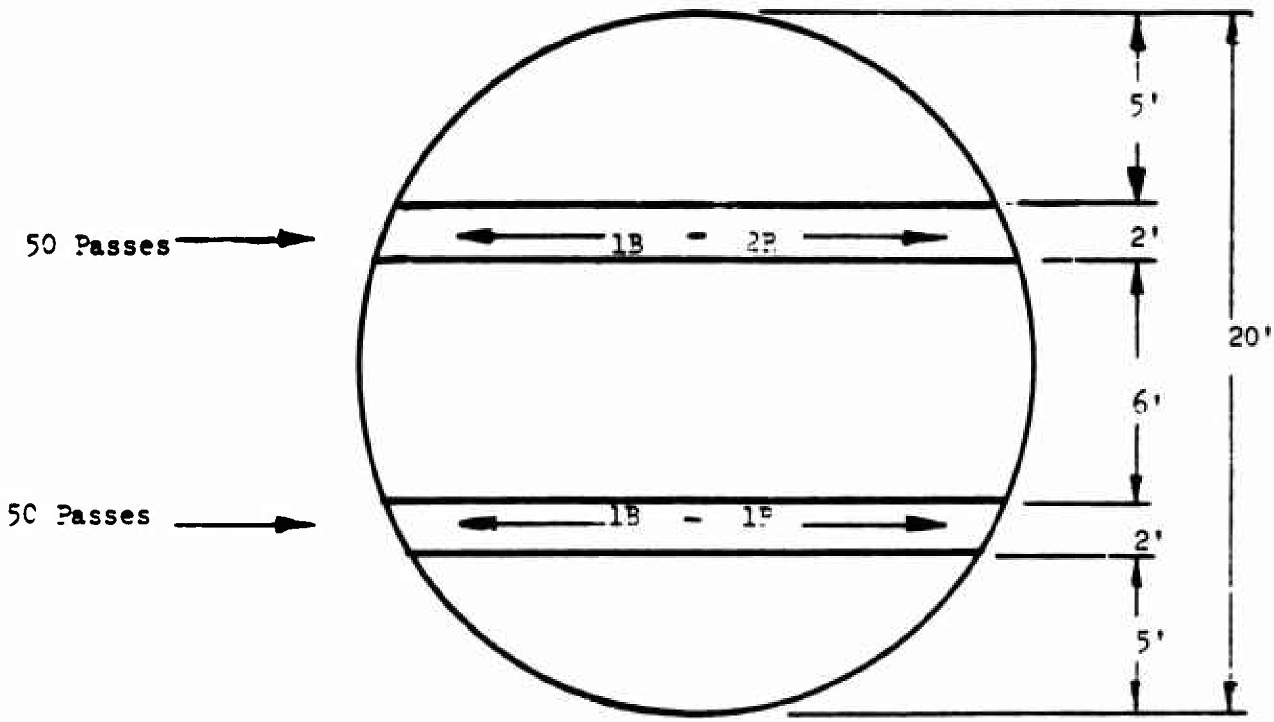


Figure A5. Top view of crater after test

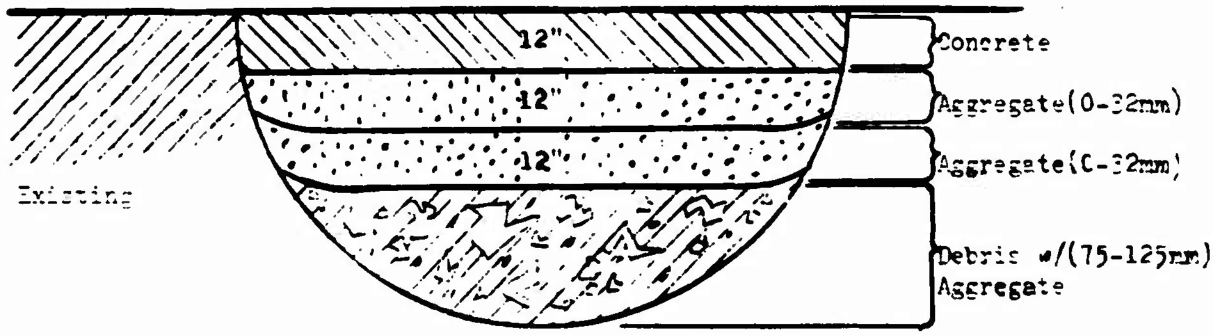


Figure A6. Actual construction of crater

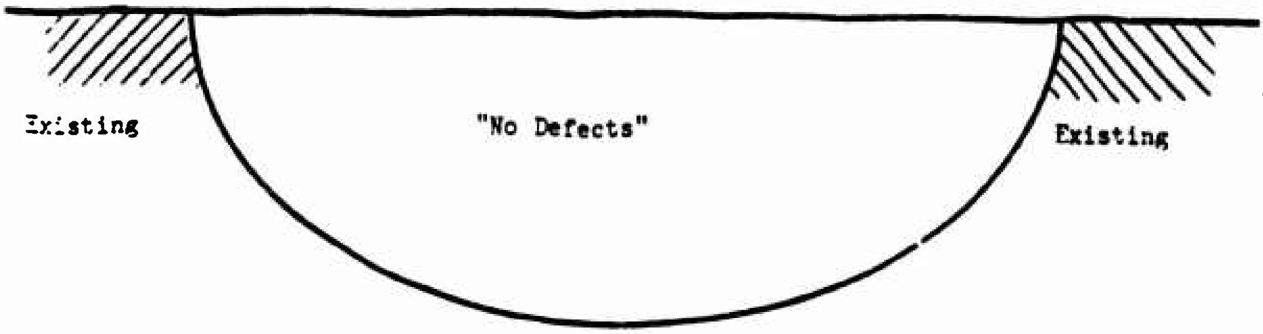


Figure A7. Side view of test strip, 1B-1R

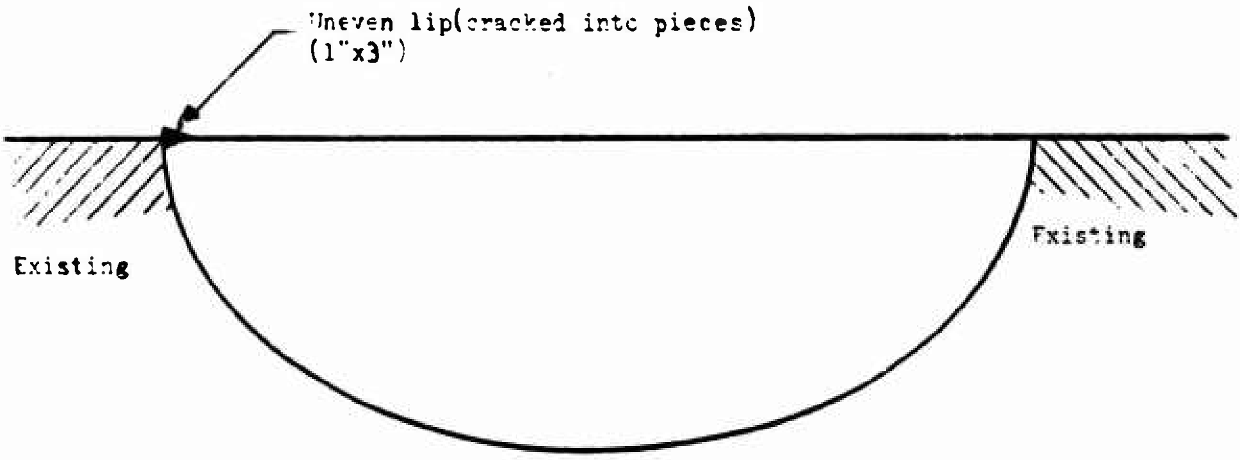


Figure A8. Side view of test strip, 1B-2R

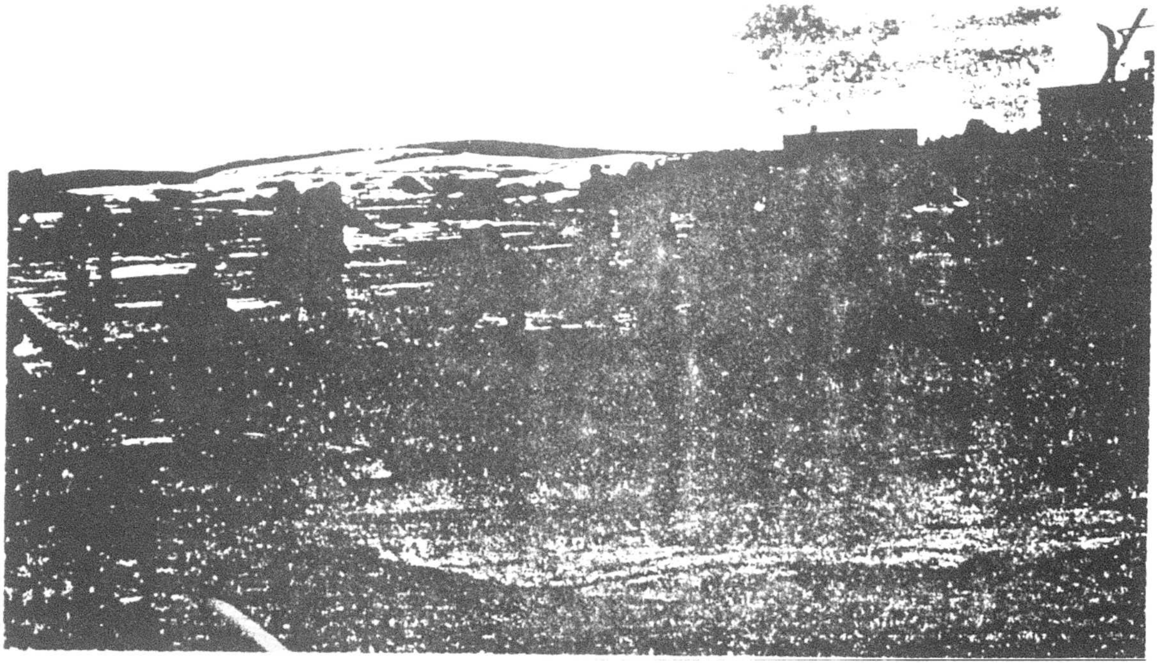


Photo A1. Completed concrete repair

Photo A2. Pumping water into crater

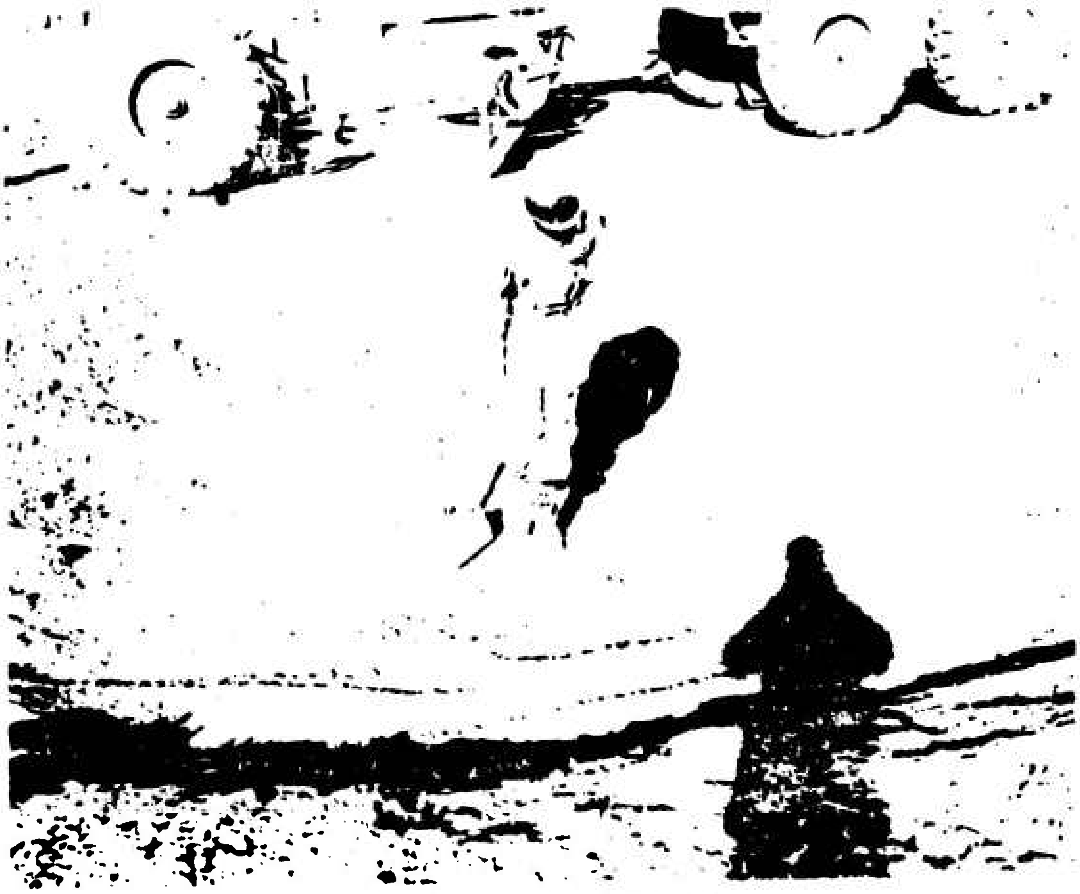


Photo A3. Compaction test

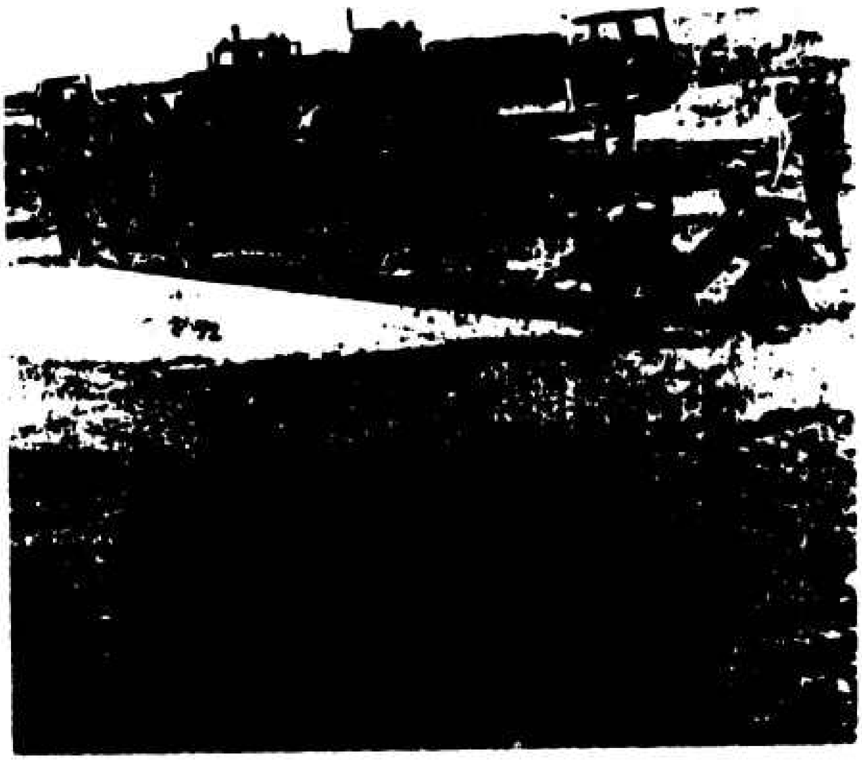


Photo A4. Initial concrete screeding

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
AEUEG-XOF	Concrete Strength Test Report

TO S-3
293d Engr Bn
APO 09034

FROM Materials Testing Sec
293d Engr Bn
APO 09034

DATE 2 Feb 81 CMT 1

Following are the results of test requested in CMT 1.

Type Test: Compressive/Flexural

Date and time of test 2 Feb 81 15:45-1605hrs

The samples were laboratory cured by Sp/4 Hadnott

beginning 3 Feb 81 1800 hrs
Date and Time

The samples were capped with ____________ on ____________
Date

Sample	Dimension(s)* ± 0.01 in.	Maximum Load	___Day Compressive/ Flexural Strength
1A 1545		500	291.67
1B 1550		520	303.33
1C 1605		585	341.25
1D	AVERAGE	535	312.08
Sample Average			
2A			
2B			
2C			
2D			
Sample Average			

*For Compressive Strength Test, dimension is cylinder diameter. For Flexural Strength Test, dimensions are span length(L), average width(B), and average depth(D).

Inclosure 1 to (81-2-1)

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
AEUEG-XOP	Concrete Strength Test Report

TO S-3
293d Engr Bn
APO 09034

FROM Materials Testing Sec
293d Engr Bn
APO 09034

DATE 16 Feb 81

CMT 1

Following are the results of test requested in CMT 1.

Type Test: Compressive/Flexural

Date and time of test 9 Feb 81 1530hrs

The samples were laboratory cured by N/A

beginning N/A (Date and Time) N/A

The samples were capped with ______ on ______ (Date)

Sample	Dimension(s)* ± 0.01 in.	Maximum Load Lbs.	7 Day Compressive/ Flexural Strength
1A		476	264.44
1B		433	240.56
1C	AVERAGE	454.50	252.50
1D			
Sample Average			
2A			
2B			
2C			
2D			
Sample Average			

*For Compressive Strength Test, dimension is cylinder diameter. For Flexural Strength Test, dimensions are span length(L), average width(B), and average depth(D).

Inclosure 2 to (81-2-1)

Technical Report 81-2-2

Field Test of Small Crater Repair Utilizing High Early Readimix Concrete

Prepared by

CPT Robert M. Devens

Headquarters, 293d Engineer Combat Battalion (HV)

18th Engineer Brigade

APO New York 09034

30 April 1981

CONTENTS

I. Materials

a. Concrete, regulated set, premixed dry, produce strength classification B35, consistency K2, in conformance with specification ZTV Beton 78 for concrete roads of construction Class I, except that the cement shall be high early cement PZ 55 DIN 1164. The air entraining agent has been omitted (see Appendix I for DIN 1164 specifications).

b. Addiment to Concrete

(1) Addiment BVF (plasticizer), liquid, quantity 4 percent of the cement weight (see Appendix O for additional information).

(2) Addiment BE-3 (accelerator), liquid, quantity 8 percent of the cement weight (see Appendix P for additional information).

c. For complete breakdown of components in the concrete, see annex A to Appendix C. The above material was purchased from:

NAHE-BETON

Lieferboton Nahe GMBH

6580 Idar-Oberstein, Bahnhofstrasse 23

d. Stone, crushed, aggregate, for road base construction, hardstone, premixed, material and mixture in accordance with "Technical Specifications and Directives for Construction for Road Bases Underwearing Courses (TVT)", grain size 0-32 mm (NSN: 5610-00-V81-0643). See Appendix H for sieve analysis data. The stone was purchased from:

Horst KORB, Am Bahnhof 15

6589 Ruschberg, Rheinland-Pfalz

II. Technique/Procedure: See Appendix C for the Technical Evaluation Outline (TEO).

III. A Company's Operation

a. Schedule of Events

0810 - Advance Party Arrived

0832 - Main Body Arrived

0836 - Began Clearing Crater Site

0850 - Began Pumping Water Out of Crater (Photo A1)

0941 - Began Filling Crater with Debris

0945 - Compacted Debris

1011 - Compaction Test

1013 - Cleaned Edge of Crater

1020 - Began Filling Crater for First Lift

1042 - Began Compaction of First Lift

1105 - Compaction Test

1109 - Began Filling Crater for Final Lift

1120 - Began Cleaning Area with Sweeper

1223 - Compacted Final Lift (Photo A2)

1242 - Compaction Test

1257 - Compacted Edges and Cleaned Edges (Photo A3)

1311 - First Concrete Truck Arrived

1323 - Second Concrete Truck Arrived

1340 - Began Mixing Concrete (Photo A4)

1347 - Third Concrete Truck Arrived

1352 - Began Placing Concrete

1410 - Began Screeding Concrete

1455 - Completed Floating Concrete

b. **Problems Encountered:** Time was lost during the lunch period. Work stopped at 1132 hr. The crew was not properly broken down into shifts.

c. **Weather Conditions:** (4 February 1981)

(1) Wind Direction - 250 deg

(2) Wind Speed - 6 knots (with gusts)

(3) Visibility - 3 miles (rain and snow)

(4) Sky Condition - 1,000-ft ceiling

(5) Temperature - 1°C (with chill factor -1°C)

d. **Results:**

LIFT INFORMATION

Test	Debris	1st Lift	2nd Lift
d	100.32	104.28	104.06
%W	12	12	12
% Compaction	80	83	83

Reading Time/Test - 1 or 2 min   Testing Depth - 6 in.

Remarks: The debris was compacted with a 5-cu yd front loader. The required compactive effort was ≥85% CE 55. The remaining two lifts were compacted with a 30-ton vibratory roller. The compactive effort required was ≥95% CE 55. The samples were taken in the middle third of the crater. The results of the concrete's flexual strength are contained in Inclosure 1 of this test packet. The quality of the crater's construction was less than required. The construction of the crater followed the technical evaluation outlined (Appendix C and Figure A1 of this test package).

The crater was tested 18-1/2 hr after its completion. No special method of

curing was employed. The cap was completely exposed to the environment. The test sample was cured under the same exposed conditions.

Test Strip 1A-1H (Figures A1 and A3) completed 50 passes. After these passes, water percolated up through the concrete in one area on the strip 23 in. long. No deflection or cracking was observed on the strip. Figure A2 shows actual construction of crater after test.

Test Strip 1A-2H (Figures A1 and A4) completed 50 passes. After three passes, water percolated up through the concrete in one area on the strip 19 in. long. No deflections or cracking was observed on the strip. Figure A5 shows the top view of the crater after test.

Analysis: If the crater was given more time to cure during hours of above-freezing temperatures, the concrete would have set up and no percolation would have occurred. The frost action slowed the curing process. The concrete in these areas must have had a higher moisture content than the other concrete, for percolation only occurred in one section of the cap (Photo A5).

The subgrade did not fail, for no deflections were observed. The compaction was 5% low for the debris lift and 12% low for both upper lifts, but this did not affect the cap or the test results.

IV. B Company's Operation

a. Schedule of Events

0730 - Advance Party Arrived

0743 - Main Body Arrived

0750 - Began Clearing Area

0820 - Began Filling Crater with 75/125 mm Aggregate

0831 - Began Clearing Edge of Crater

0858 - Began Compaction of Debris

0920 - Compaction Test

0922 - Began Filling Crater for First Lift

0938 - Began Compaction of First Lift

0947 - Compaction Test

0950 - Began Filling Water for Final Lift (Photo A6)

1023 - Began Cleaning Edge (Photo A7)

1128 - Began Compaction of First Lift

1038 - Recompacted Final Lift

1048 - Compaction Test

1053 - Recompacted Edge of Crater

1115 - Finished Cleaning Edge of Crater (Photo A8)

1252 - First Concrete Truck Arrived

1305 - Second Concrete Truck Arrived

1313 - Began Mixing Trucks (Photos A9 and A10)

1319 - Third Concrete Truck Arrived

1322 - Began Placing Concrete (Photo A11)

1358 - Began Screeding Concrete

1425 - Began Floating Concrete (Photos A12 and A13)

1535 - Completed Reparation of Crater

b. Problems Encountered: The only delay of this operation was the arrival of the concrete truck. A delay of 1 hr and 37 min was due to the arrival time of the first concrete truck. The crater was ready for concrete at 1115 hr.

c. **Weather Conditions:** (11 February 1981)

Wind Direction - 360 deg

Wind Speed - 4 knots

Visibility - 5 miles (unlimited)

Sky Condition - 3,500-ft ceiling

Temperature - 5°C high/0°C low

d. **Results:**

LIFT INFORMATION

Test	Debris	1st Lift	2nd Lift
d	110.46	110.88	115.92
% W	16	16	16
% Compaction	88.37	88.70	92.74

Reading Time/Test - 1 or 2 min Testing Depth - 6 in.

Remarks: The debris was compacted with a 5-cu yd front loader. The required compaction effort was ≥85% CE 55. The debris fill was supplemented with large aggregate (75-125 mm) since the moisture content was high and the crater had 4 in. of standing water. With the aggregate, the actual compaction effort met the requirement. The remaining lifts were compacted with a 30-ton vibratory roller. To prevent percolation of the water through the soil, the vibrator was not turned on. The first lift reached 86.7%, not the 95% required, and the second lift reached 92.7%, not the ≥95% required (Figure A6). The samples were taken near the center third of the crater. The results of the concrete's flexural strength test are contained in Inclosure 2 of this test package. The crater was constructed to the specification in the

technical evaluation outline (Appendix C) with the exception of the debris lift. Large aggregate was used to increase the compaction effort (Figure A6).

The crater was tested 19 hr after its completion. No special method of curing was employed, the cap was completely exposed to the environment. The test sample was cured under the same conditions.

Test Strip 1B-1H (Figures A5 and A7) completed 50 passes. No deflections or cracks were observed. The strip showed no signs of being affected by the cold weather (Photo A14 for illustration). Test Strip 1B-2H (Figures A5 and A8) completed 50 passes. No deflections or cracks were observed. The strip showed no signs of being affected by the cold weather. The only concrete failure occurred at the outer edge of the crater. The existing concrete failed at the edge leaving a small depression. This depression caused the now exposed edge of the new cap to crack off. The entire failure on the cap's edge was 1-1/2 in. deep, 11 in. long, and 4 in. wide.

Analysis: The concrete cap had no deficiencies except for the small fracture at the crater's edge. The crater had 4 in. of standing water prior to repair. The debris was saturated. The large aggregate enabled the company to achieve the goal of $\geq$85% CE 55 compactive effort. The other lift did not obtain the required compactive effort but this had no effect on the test results. No deflections were observed; therefore, the subgrade did not fail.

The failure at the edge was caused by the collapse of the existing concrete. This failure caused the shear to be greater than what the new concrete could support; therefore it broke off.

V. Recommendations:

a. During very cold weather conditions, appropriate curing methods need to be added to the TEO (Appendix C). The use of a plastic film (10 mil polyethelene) or straw would have produced better curing results.

b. The use of the vibratory roller without the vibrator unit turned on worked well on the aggregate despite the high moisture content.

c. The procedure of placing large aggregate (75-125 mm) in the water-saturated debris worked extremely well. The requirement of ≥85% CE 55 was achieved using this method. This procedure should be written in the TEO (Appendix C) as a contingent method if inclement weather should occur. This process would save time and effort for the compactive effort required can be reached quicker and the possibility of entrapping a vehicle is reduced.

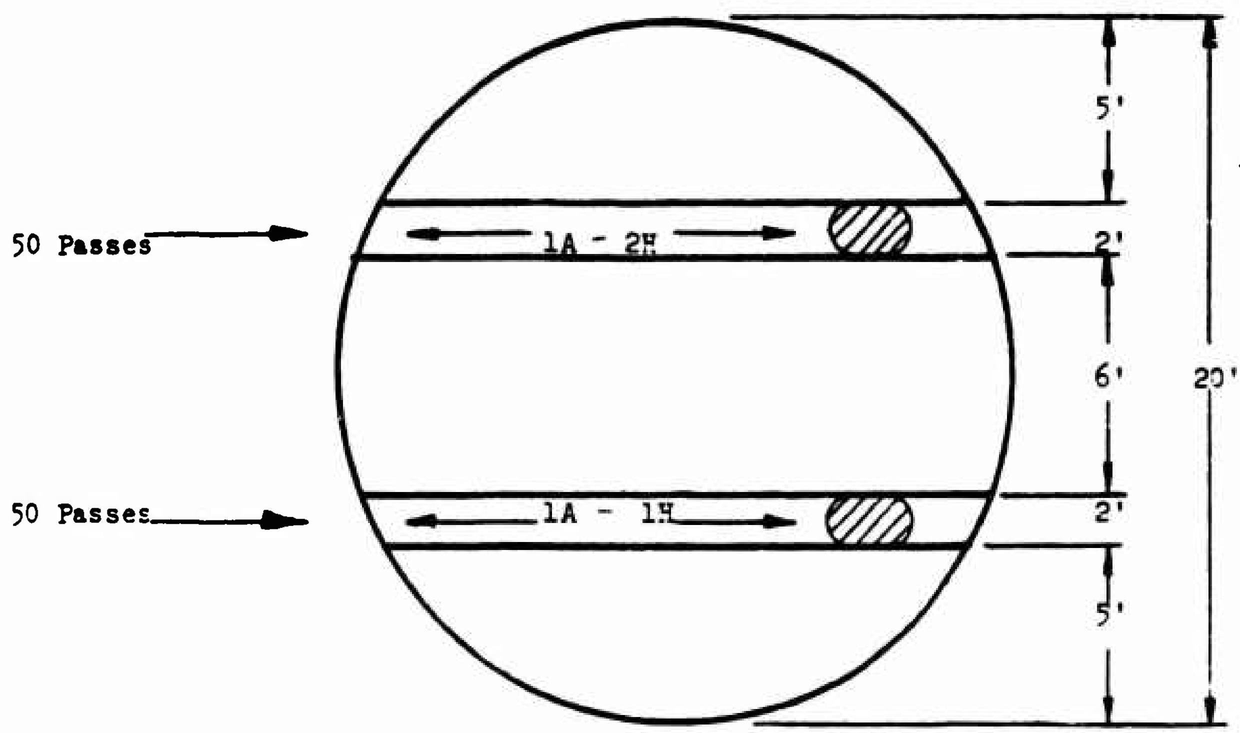


Figure A1. Top view of crater after test

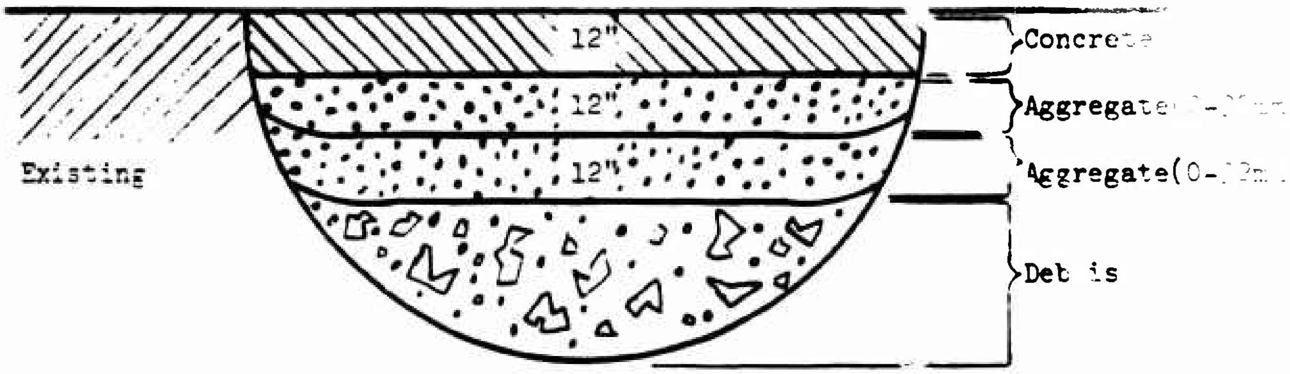


Figure A2. Actual construction of crater after test

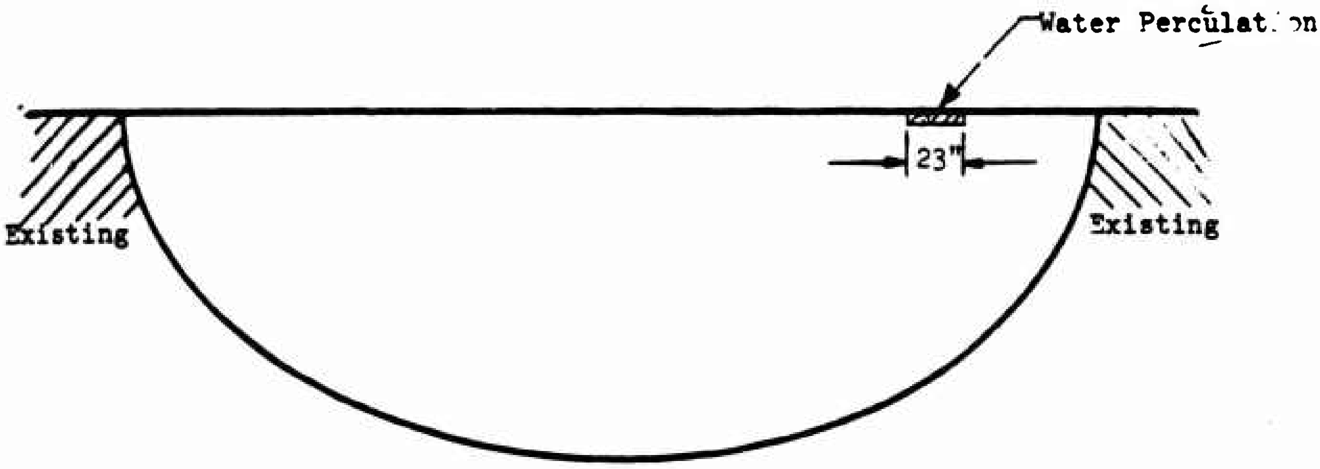


Figure A3. Side view of test strip 1A-1H

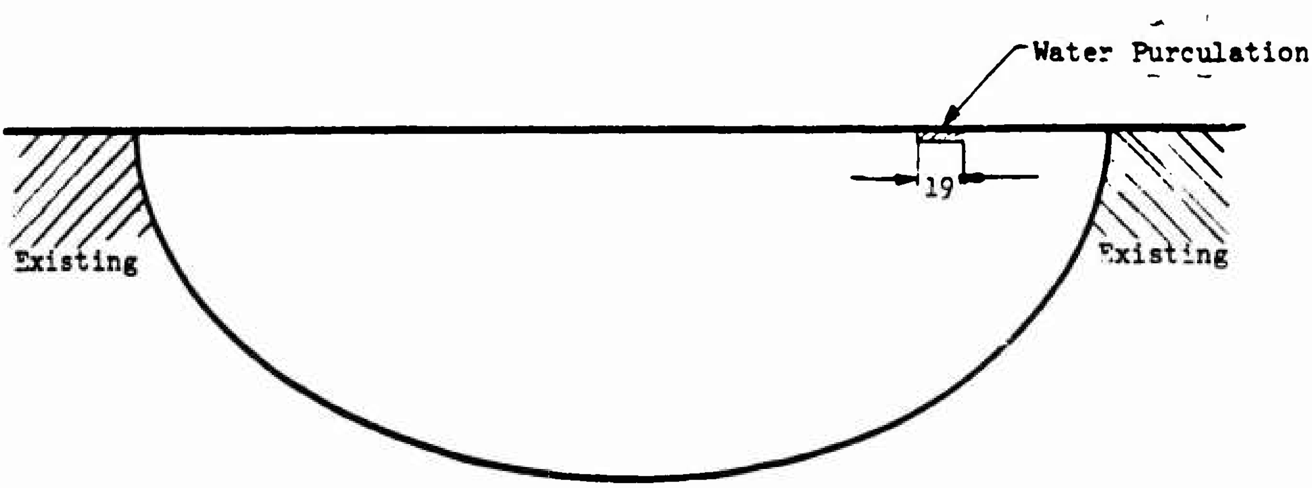


Figure A4. Side view of test strip 1A-2H

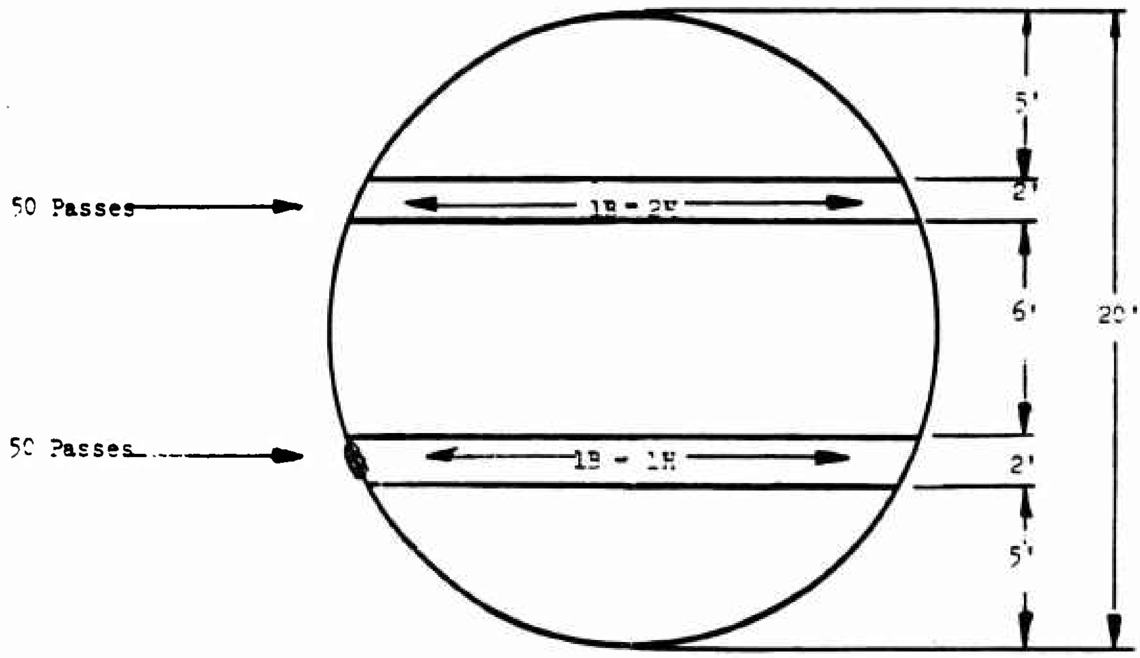


Fig -e A5. Top view of crater after test

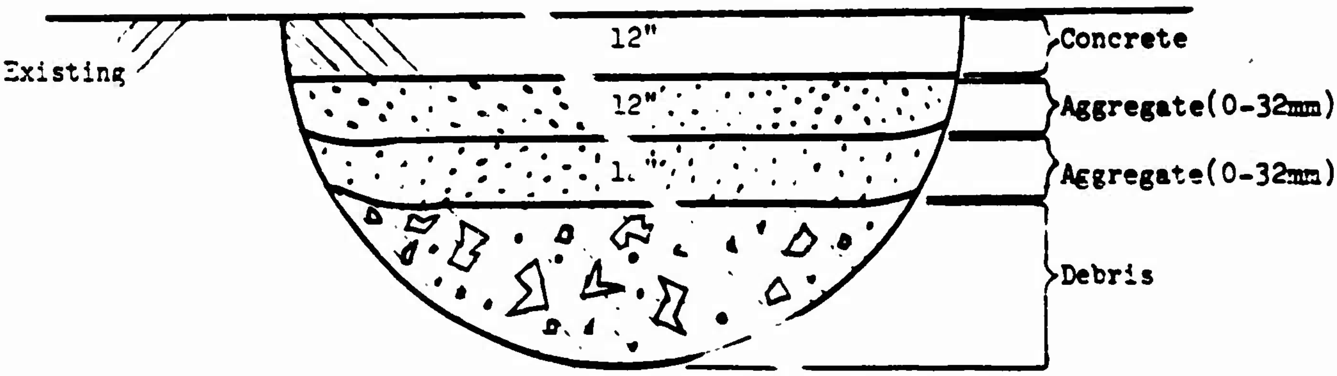


Figure A6. Actual construction f crater

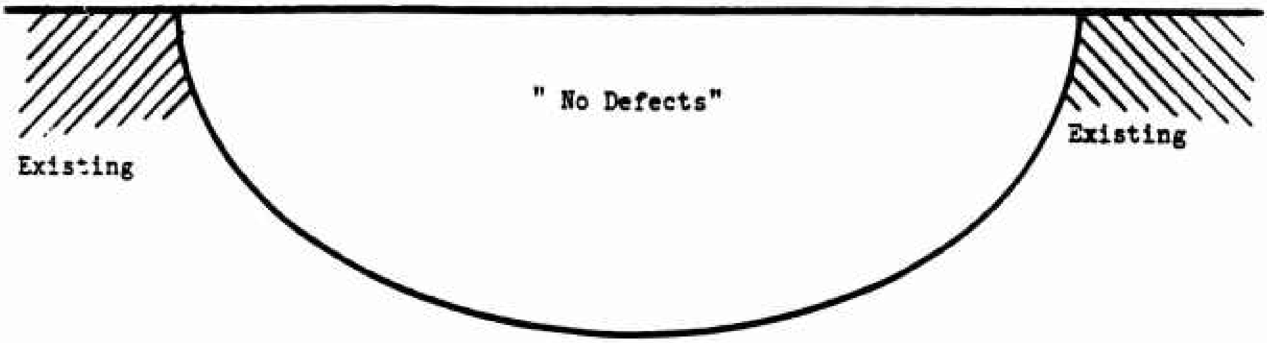


Figure A7. Side view of test strip 1B-1H

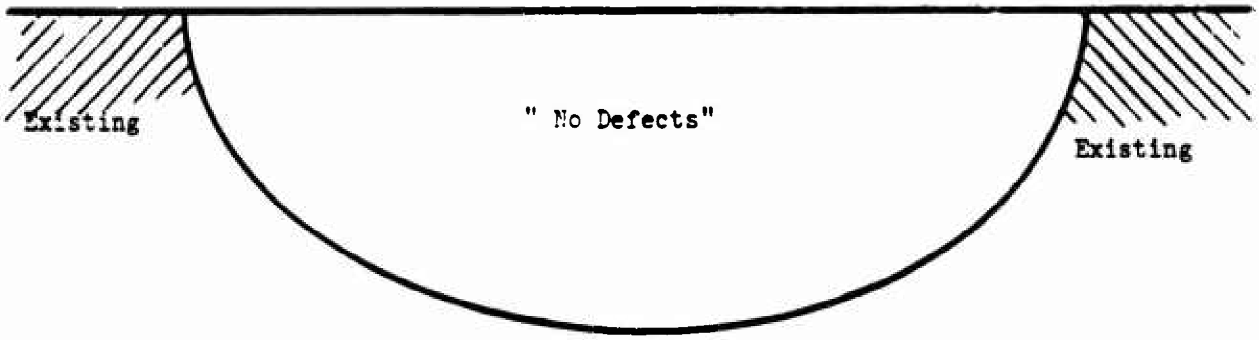


Figure A8. Side view of test strip 1B-2H

Photo A1. Pumping water out of crater

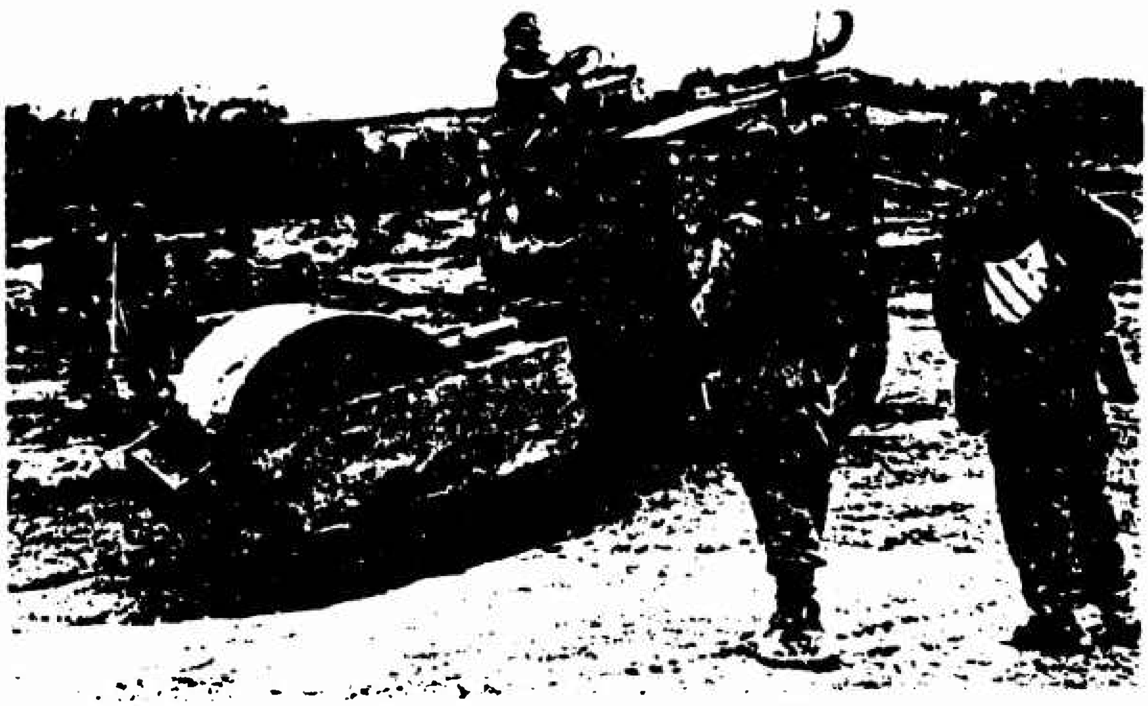


Photo A2. Compacted final lift

Photo A3. Compacting and cleaning edges

Photo A4. Mixing concrete

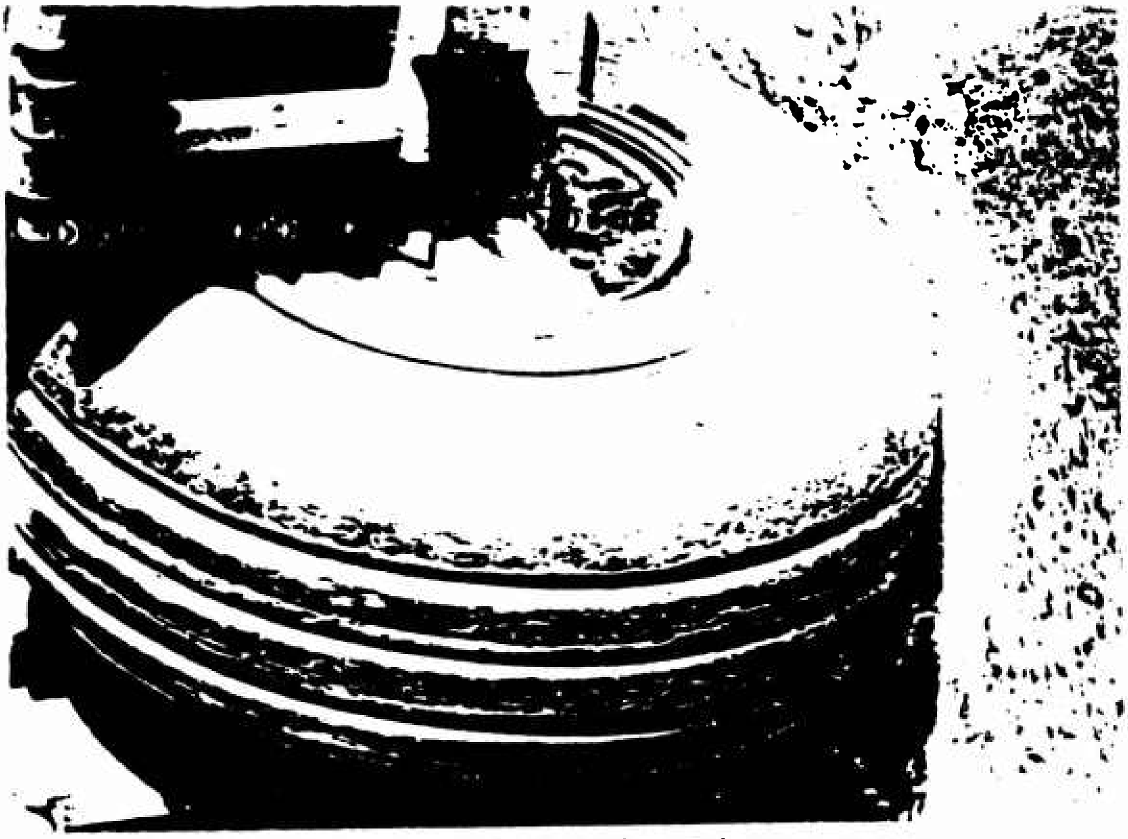


Photo A5. Percolation with higher moisture content

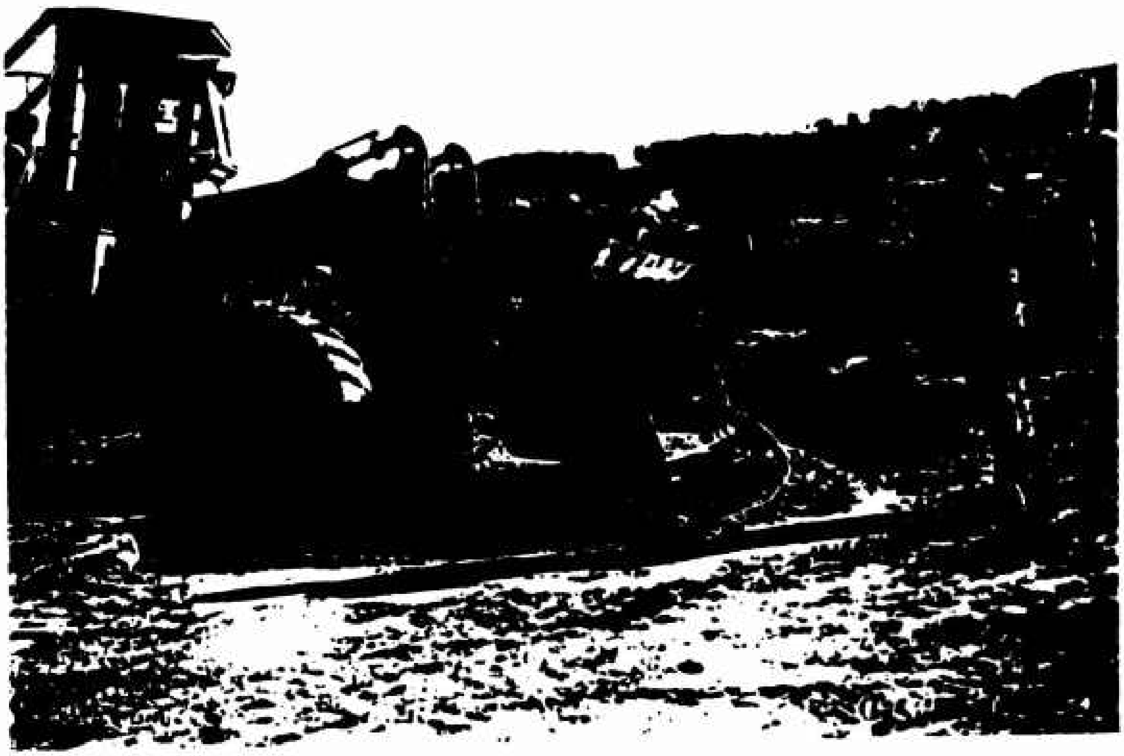


Photo A6. Filling water for final lift

Photo A7. Cleaning crater edge

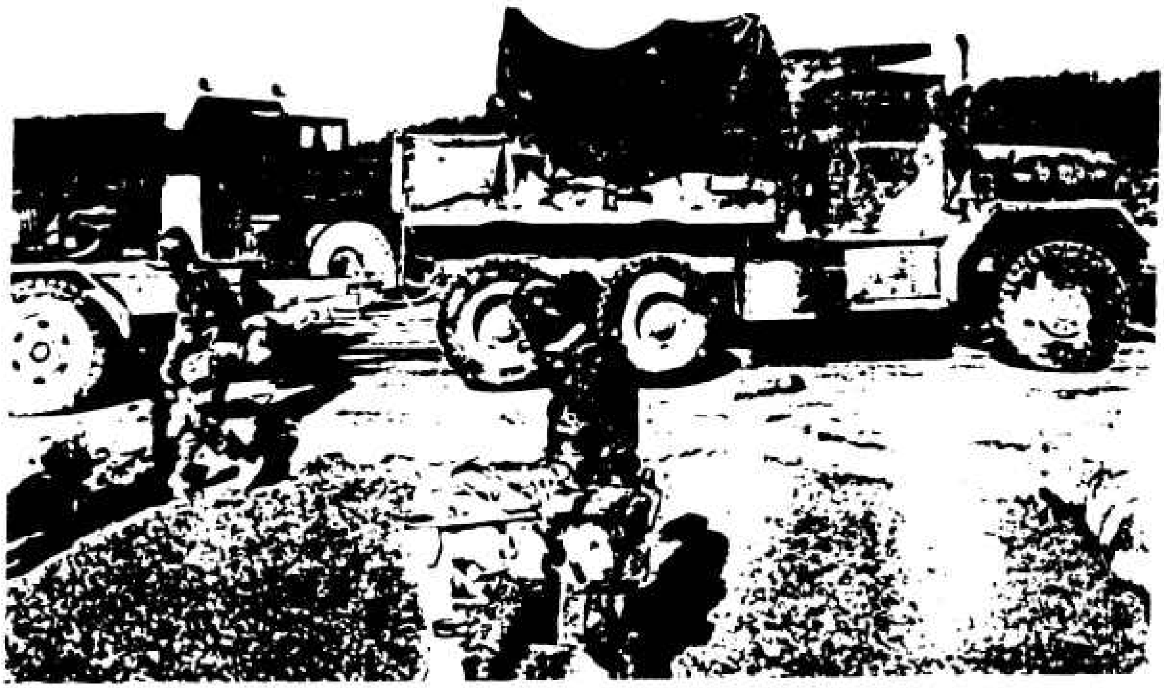


Photo A8. Cleaning edge of crater

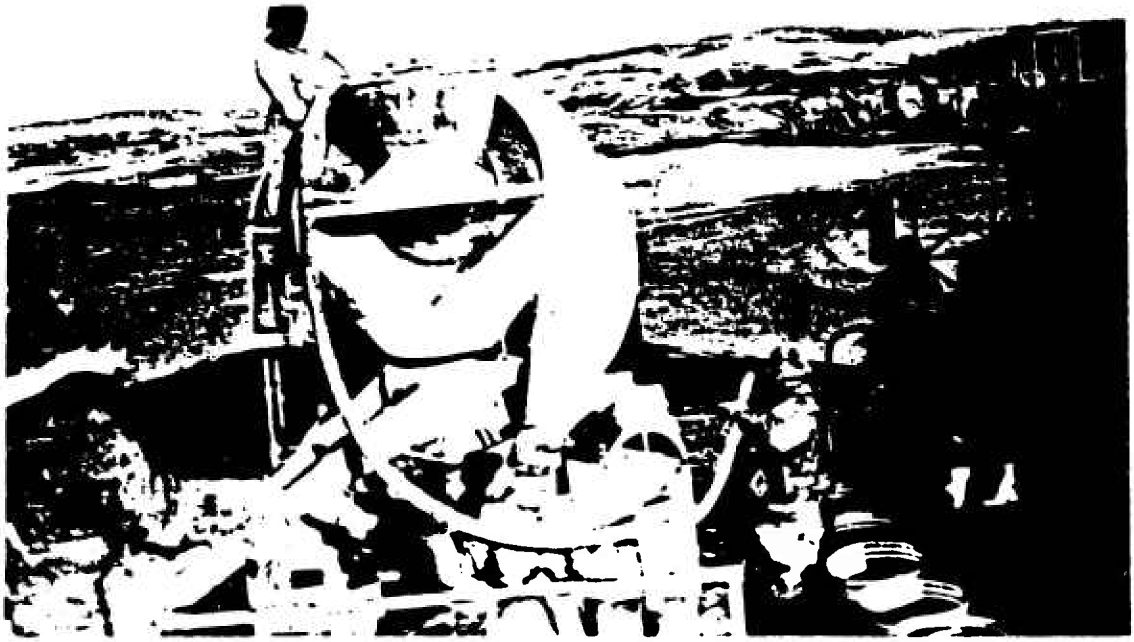


Photo A9. Mixing truck charging

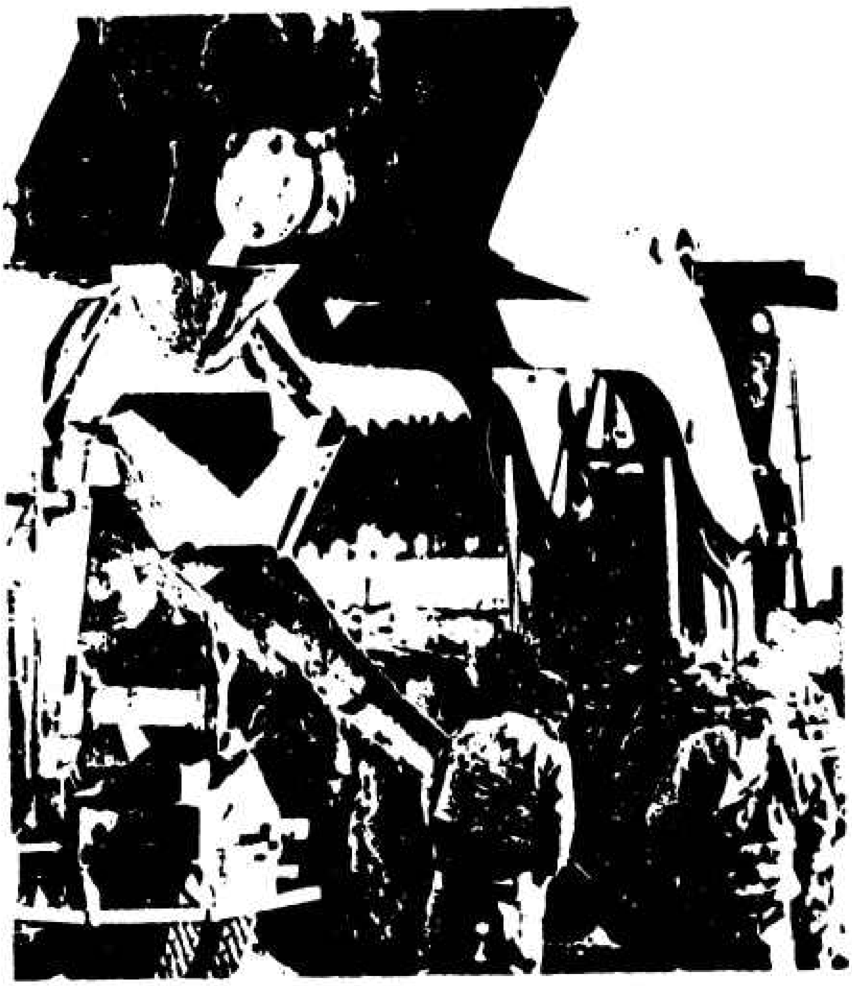


Photo 10. Mixing truck operation

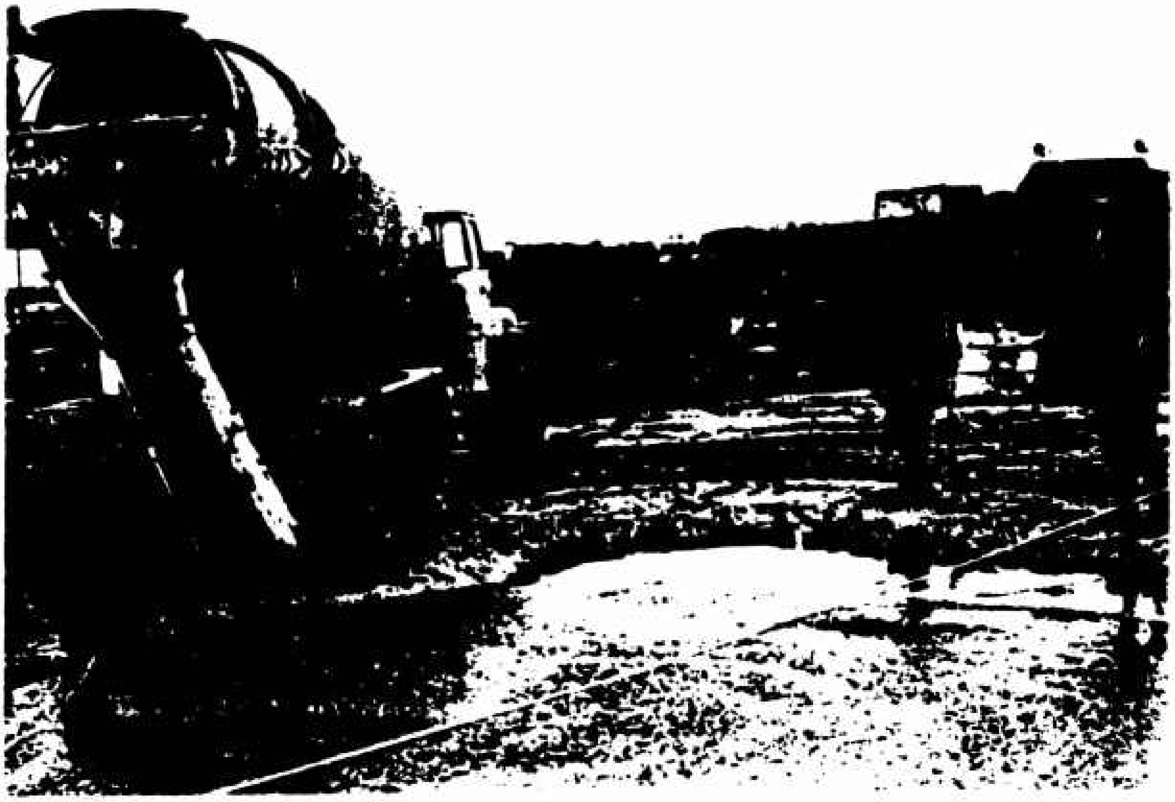


Photo A11. Initial concrete placement

Photo A12. Initial concrete floating

Photo A13. Concrete finishing

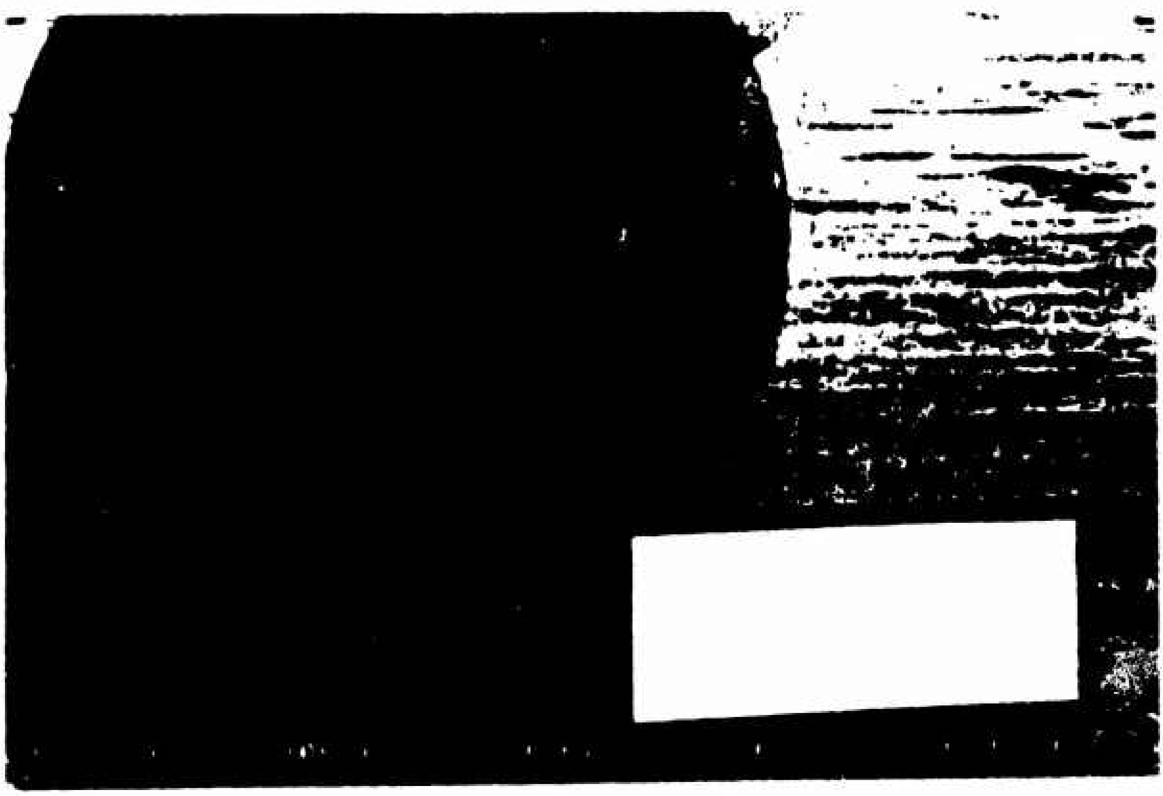


Photo A14. Load testing of repair

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
AEUEG-XOP	Concrete Strength Test Report

TO		FROM		DATE		CMT 1
	S-3 293d Engr Bn APO 09034		Materials Testing Sec 293d Engr Bn APO 09034		12 Feb 1981	

Following are the results of test requested in CMT 1.

Type Test: Compressive/Flexural

Date and time of test 5 Feb 81 16:50 hrs

The samples were laboratory cured by N/A

beginning N/A
Date and Time

The samples were capped with N/A on N/A
Date

Sample	Dimension(s)* ± 0.01 in.	Maximum Load	7 Day Compressive/ Flexural Strength
1A		500	277.78
1B		479	266.11
1C		488	271.11
1D	AVERAGE	489	271.67
Sample Average			
2A			
2B			
2C			
2D			
Sample Average			

*For Compressive Strength Test, dimension is cylinder diameter. For Flexural Strength Test, dimensions are span length(L), average width(B), and average depth(D).

Inclosure 1 to 81-2-3

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
AEUEG-XOP	Concrete Strength Test Report

TO S-3
293d Engr Bn
APO 09034

FROM Materials Testing Sec
293d Engr Bn
APO 09034

DATE 18 Feb 81 CMT 1

Following are the results of test requested in CMT. 1.

Type Test: Compressive/Flexural

Date and time of test 11 Feb 81 13:30 hrs

The samples were laboratory cured by N/A

beginning N/A
Date and Time

The samples were capped with N/A on N/A
Date

Sample	Dimension(s)* ± 0.01 in.	Maximum Load	7 Day Compressive/ Flexural Strength
1A		464	252.22
1B		601	333.89
1C	AVERAGE	532.50	293.05
1D			
Sample Average			
2A			
2B			
2C			
2D			
Sample Average			

*For Compressive Strength Test, dimension is cylinder diameter. For Flexural Strength Test, dimensions are span length(L), average width(B), and average depth(D).

Inclosure 2 to (81-2-2)

Technical Report 81-2-3

Field Test of Small Crater Repair Utilizing Grout and Stone Mix

Prepared by

CPT Robert M. Devens

Headquarters, 293d Engineer Combat Battalion (HV)

18th Engineer Brigade

APO New York 09034

30 April 1981

CONTENTS

I. Materials

a. Cement, Portland, PZ35F, DIN 1164 (see Appendix I for DIN 1164).

b. Stone, crushed, hard durable, weather resistant, compressive strength in moist condition 150 N/mm minimum, DIN 52100, grain size 75-125 = (NSN 5610-00-V81-0637) (see Appendix L for DIN 52100).

The above items, a and b, were purchased from:

RAAB KARCHER GMBH, Savignytr .5

6000 Frankfurt-1

c. ADDIMENT BE-3 accelerator (see Appendix P for more information).

d. ADDIMENT BE-3 concentrate, dry flakes (see Appendix P for more information).

The above named items, c and d, were purchased from:

NAHE-BETON

Lieferbeton Nahe GMBH

6580 Idar-Oberstein, Bahnhofstrasse 23

e. Stone, crushed, aggregate, for road construction, base course material, hardstone, ready mixed, material and mixture in accordance with "Technical Specifications and Directives for Execution of Base Courses in Road Construction TVT 72", grain size 0-45 mm, (NSN 5610-00-V52-0130) (see Appendix H for seive analysis data.)

Item e was purchased from:

HORST KORB, Am Bahnhof 15

6589 Ruschberg, Rheinland-Pfalz

f. Plastic film, Visqueen, 10 mil polyethelene.

The above item f was purchased from:

Director of Engineering/Housing

Baumholder, Germany

APO New York 09034

II. Technique/Procedure: See Technical Evaluation Outline, appendix C.

III. A Construction:

a. Construction Sequence

Morning - Area Cleared and Secured

1305 - Cleared Debris

1322 - Began Filling Crater with Debris

1330 - Cleaned Crater's Edge

1400 - Compacted Debris

1405 - Compaction Test

1410 - Began Filling Crater with Aggregate for First Lift

1415 - Began Charging Concrete Mobile Mixer

1415 - Compacted First Lift

1425 - Compaction Test

1432 - Began Filling Crater with Aggregate for 2nd Lift

1515 - Compacted 2nd Lift

1537 - Compaction Test

1542 - Cleaned Edge

1545 - Placed Sand Around Edge of Crater

1550 - Placed Polyethelene Sheet over 2nd Lift (Photo A1)

1610 - Began Placing Grout

16?2 - Placed Large Stone on Grout

1913 - Placed 0-32 mm Aggregate to 1/3 of Crater to Bury Grout Level with Existing Pavement

1926 - Began Floating Crater

1945 - Began Finishing of Crater

2009 - Completed Crater Repair

b. Problems Encountered:

(1) Personnel were inexperienced on the use of the new concrete mobile mixer.

(2) The clutch to one concrete mobile mixer was inoperable.

(3) The charging operation of the concrete mobile mixer was started late and takes over half an hour.

(4) A shortage of grout caused delay for aggregate (0-32 mm) - had to be added to one third the crater for the last 4 in. More cement was on site but was not used to charge the concrete mobile mixer.

c. Weather Conditions: (2 February 1981)

(1) Wind Direction - 222 deg

(2) Wind Speed - 2 knots (no gusts)

(3) Visibility - 7 miles (unlimited)

(4) Sky - Clear (no ceiling)

(5) Temperature - 7°C(no wind chill factor)

d. Results:

LIFT INFORMATION

	Debris	1st Lift	2nd Lift
d	99.12	88.88	109.56
% W	12	12	12
% Compaction	78.5	71.1	87.6

Reading Time/Test - 1 or 2 min   Testing Depth - 6 in.

Remarks: The debris was compacted by a 5-cu yd front loader. The required compaction effort was ≥85% CE 55. The loader achieved a compactive effort of ≥75% of CE 55. The other lifts were compacted with a 30-ton vibratory roller. The required compaction effort was ≥95% CE 55. The first lift achieved 71.7% and the second lift achieved 87.6%. The samples were taken from the middle third of the crater.

The crater was tested 18 hr after its completion. A polyethelene cover (10 mil) was placed over the cap to prevent frost action. This was the only curing method used on the cap. Photo A2 illustrates the cross section of the grout/stone mixture. This photo was taken after the grout/stone cap was removed 69 hours after the crater's completion.

Test Strip 1A-1H (Figures A1 and A3) completed 50 passes. The cap had surface cracks that had a depth of 1/16 inch. No depressions or slurrs formed under the pressure of the test vehicle. No deflections were observed. The area in

which the aggregate (0-32mm) was added had no surface cracks. This mixture was over 1/2 the strip (Photo A3). Figure A2 shows the actual construction of the crater.

Test Strip 1A-2H (Figures A1 and A4). The results were identical to 1A-1H but only about 1/5 of the strip had the aggregate (0-32 mm) mixture.

Analysis: After 18 hr, the crater held with no deflections. The surface cracks did not affect the performance of the crater. The failure to reach the required compaction efforts did not affect the cap. The debris was 6.5% low, the first lift 23.9% low, and the final lift was 7.4% low. Curing the concrete by the placement of the polyethelene sheet assisted greatly in reducing the frost action. As shown in the cap constructed by B Company, not using the polyethelene sheet greatly altered the results.

III. B Co Operation:

a. Schedule of Events

0750 - Advance Party Arrived

0800 - Main Body Arrived

0805 - Began Clearing Crater

0809 - Began Filling Crater with Debris

0830 - Compaction of Debris

0842 - Compaction Test

0844 - Began Filling Crater with Aggregate for 1st Lift

0846 - Cleaned Edge

0919 - Compaction of 1st Lift

0928 - Compaction Test

0930 - Began Charging Concrete Mobile Mixer

0935 - Began Filling Crater with Aggregate for 2nd Lift

1000 - Compacted 2nd Lift

1010 - Compaction Test

1020 - Added More Fill to 2nd Lift

1030 - Recompacted 2nd Lift

1040 - Compaction Test

1045 - Cleared Edge and Compacted Edge

1050 - Placed Sand Edge

1102 - Placed Polyethelene on Top of 2nd Lift

1141 - Began Placing Grout (Photo A4)

1311 - Began Placing Aggregate (75-125 mm)

1352 - Continued to Place Grout (Photo A5)

1709 - Added Aggregate (0-32 mm) to Top 3 in. of Grout

1842 - Began Floating Cap

1902 - Began Finishing Cap

1917 - Completed Crater

b. Problems Encountered:

(1) Personnel were inexperienced on the use of the new concrete mobile mixer.

(2) A charged mobile mixer, when ready to pour, became inoperable.

(3) The polyethelene was not on hand when required.

(4) The water truck was not topped off and could not charge the mobile mixer. This caused a 42-min delay.

(5) The concrete had crusted and had to be tamped before being placed in mobile mixers.

(6) A shortage of grout caused a delay for 0-32 mm aggregate had to be added to the top 2 in. of the cap. Shortage was due to one charged mobile mixer becoming inoperable.

(7) Personnel and the concrete finishing tools were not at the crater location and over 30 min was lost trying to regroup the detail.

c. Weather Conditions: 10 February 1981

Wind Direction - 240 deg

Wind Speed - 8-10 knots

Visibility - unlimited

Sky - 1,000-ft ceiling

Temperature - high 3°C, low 1°C

d. Results

LIFT INFORMATION

	Debris	1st Lift	2nd Lift
d	105.82	109.14	104.28
% W	17	17	17
% Compaction	88.16	90.95	83.2

Reading Time/Test - 1 or 2 min   Testing Depth - 6 in.

Remarks: The debris was compacted with a 5-cu yd loader. The required compaction effort was ≥85% CE 55. The standard was achieved. The other lifts of aggregate were compacted with a vibratory roller with the vibrating unit off. The first lift was 4% short and the second lift 12% short of the ≥95% CE 55. The moisture content was too high to use the vibrator on the 30 ton vibratory roller. The samples were taken in the middle third of the crater. No tests of the grout-stone mixture were made in the crater itself. The construction of the crater followed the technical evaluation outline until the final cap. Aggregate (0-46 mm) was added to the top 3 in. of the cap to compensate for the lack of grout (see Appendix D and Figure A6 of this test package).

The crater was tested 20 hr after its completion. No special method of curing was employed as was done in A Company's grout repair. A polyethelene sheet was not placed over the crater cap. The cap was completely exposed to the environment. The difference in the results was tremendous.

Test Strip 2B-1 (Figures A5 and A7) completed 50 passes. The test vehicle left tracks through the strip. These were 1/2 to 1 in. deep the entire length of the strip. In one area, a depression formed. The maximum depth of that depression was 3 in. The depression stopped where the large rocks were located. No deflections or cracks were observed. The subgrade did not fail.

Test Strip 2B-2 (Figures A5 and A8) completed 50 passes. The test vehicle left tracks through the strip that were 1/2 to 1 in. deep the entire length of the strip. In two areas, depressions formed. The maximum depth of both depressions was 3 to 3-1/2 in. The depression stopped where the larger

aggregate (75-125 mm) was located. No deflections or cracks were observed. The subgrade did not fail (Photo A6).

e. Analysis: The key item to note was the difference in the results. The only difference in procedure was the curing method used in A Company's construction. If the crater had been given more time to cure during hours of above freezing temperatures, the depression and tracks would not have occurred. The top layer had frozen. The frozen material held for a short while until friction between the surface and the test vehicle caused the failure. The subgrade's compaction did not meet the standards outlined in the TEO, but did not cause the crater to deflect.

V. Recommendations:

a. Due to very cold or very hot conditions, proper curing methods need to be added to the TEO. The use of a plastic film (10 mil polyethelene) or straw would have produced better results.

b. Both crater's subgrades did not reach the standards of compaction required by the TEO. No deflections were observed, so to save time the standards could be reduced by at least 5% on all lifts. A standard of allowable water contents in the lifts should be added to the TEO.

c. A contingent method of adding small size aggregate to the grout for the last 2-3 in. of the crater cap should be placed in the TEO in case a shortage of grout occurs.

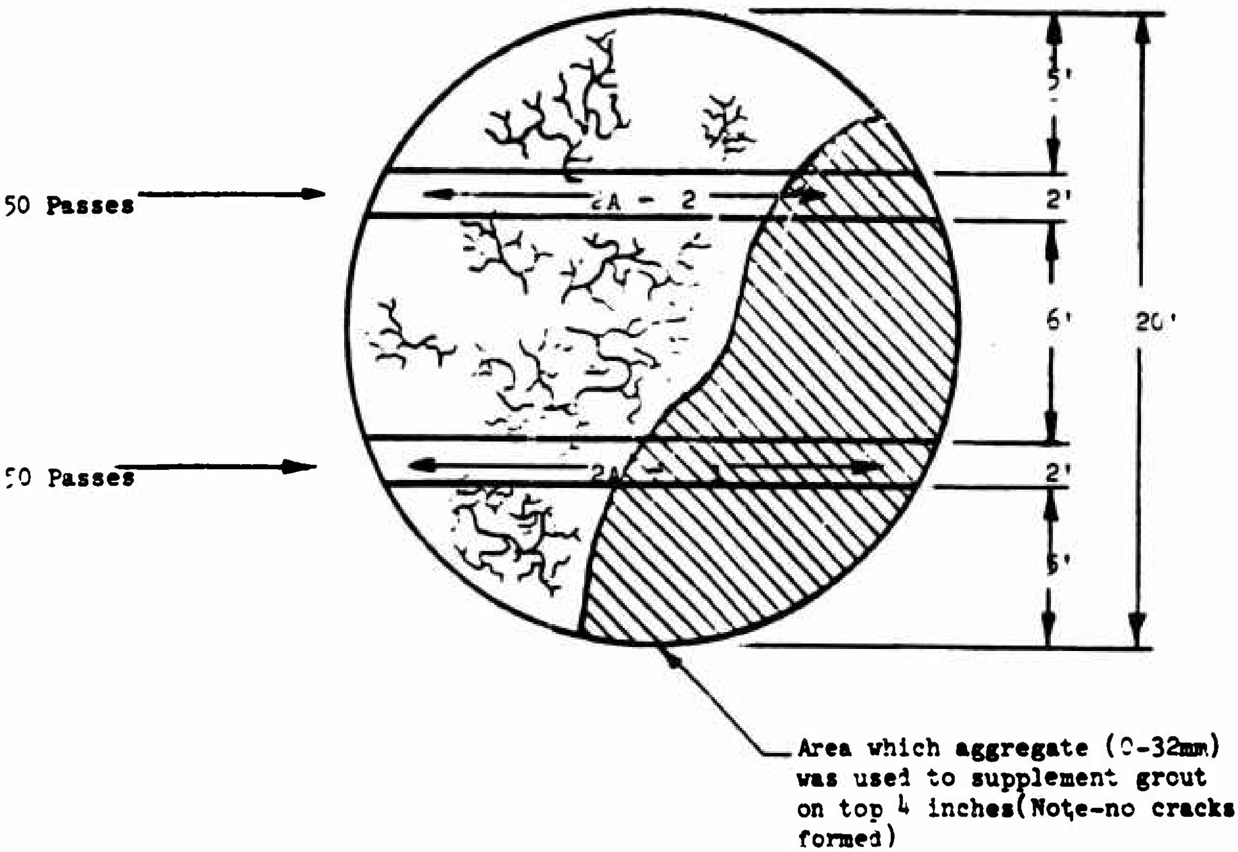


Figure A1. Top view of crater after test

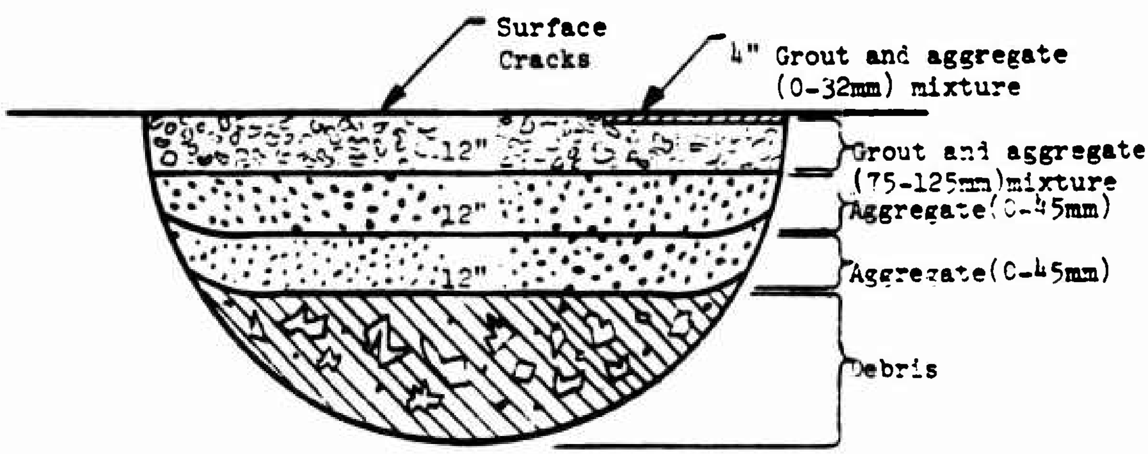


Figure A2. Actual construction of crater

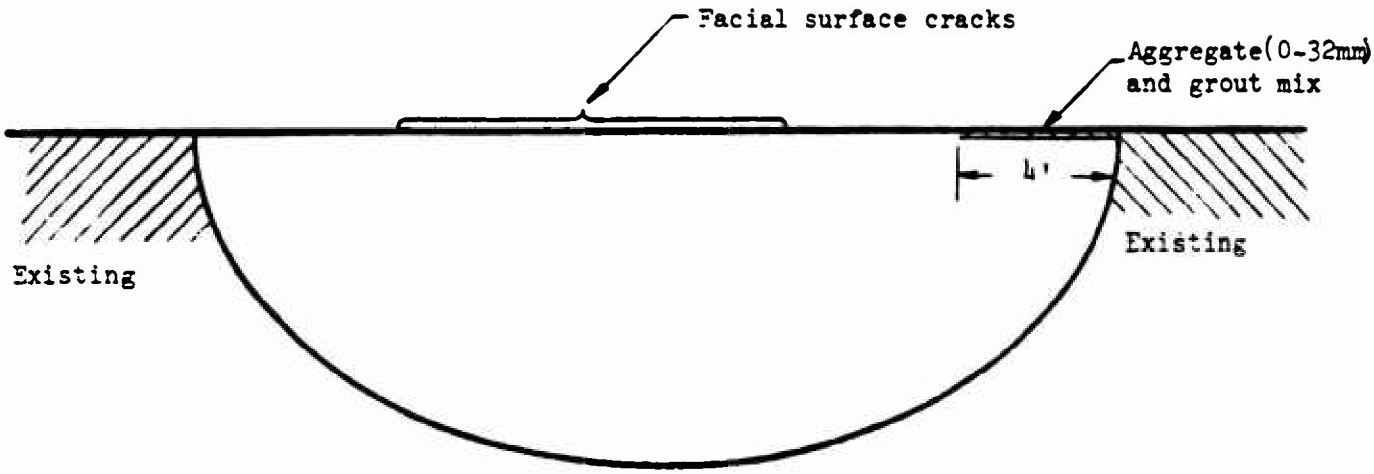


Figure A3. Side view of test strip 1A-1H

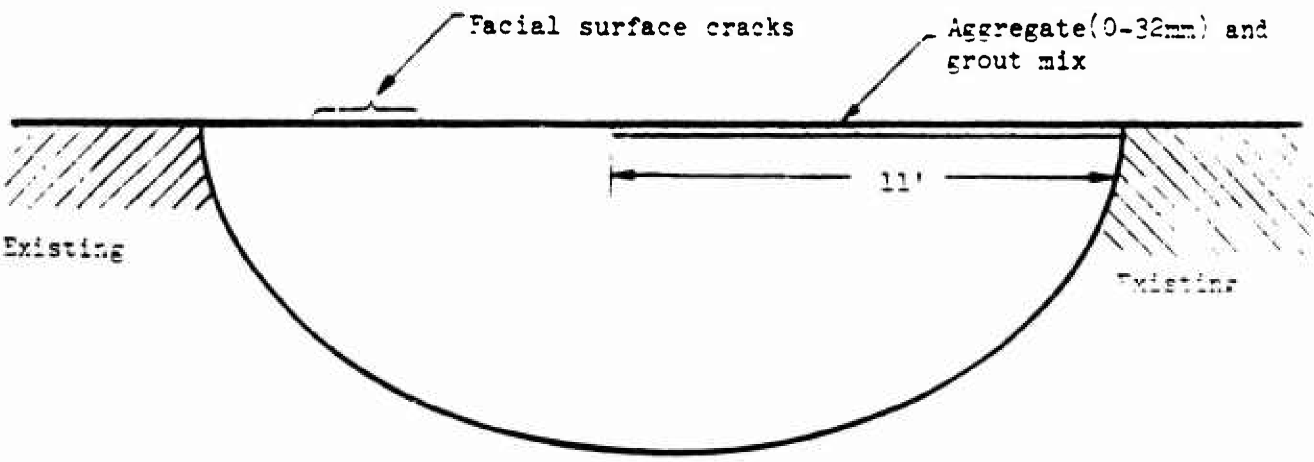


Figure A4. Side view of test strip 1A-2H

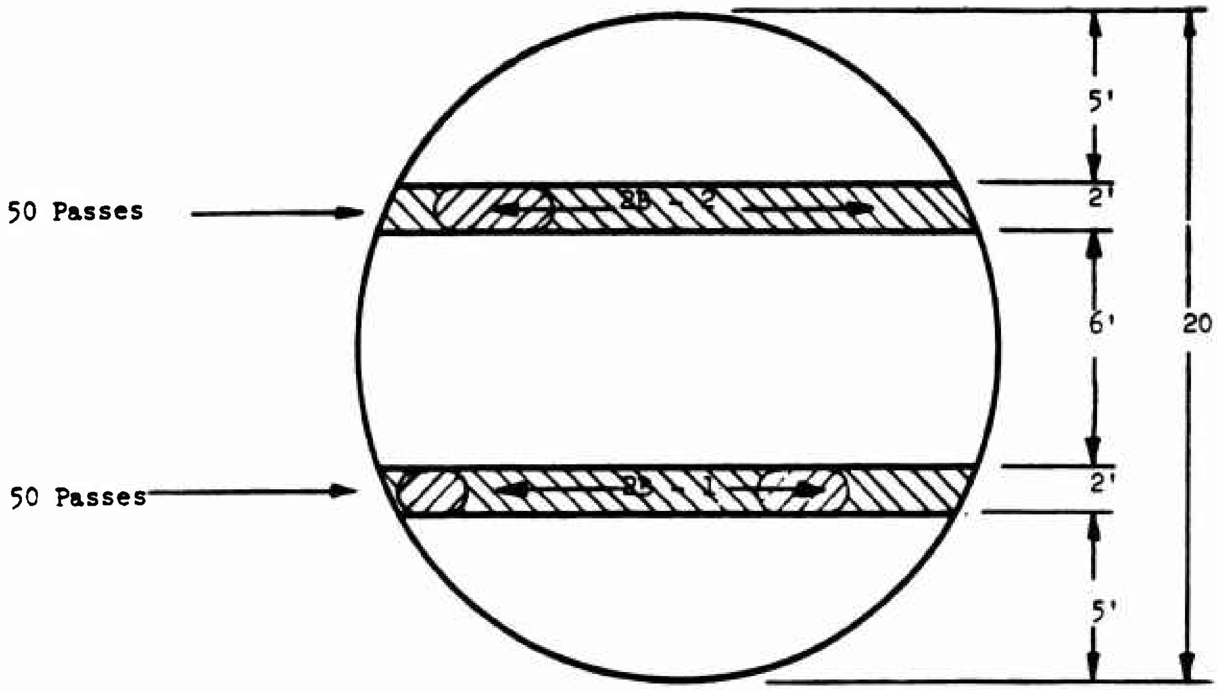


Figure A5. Top view of crater after test

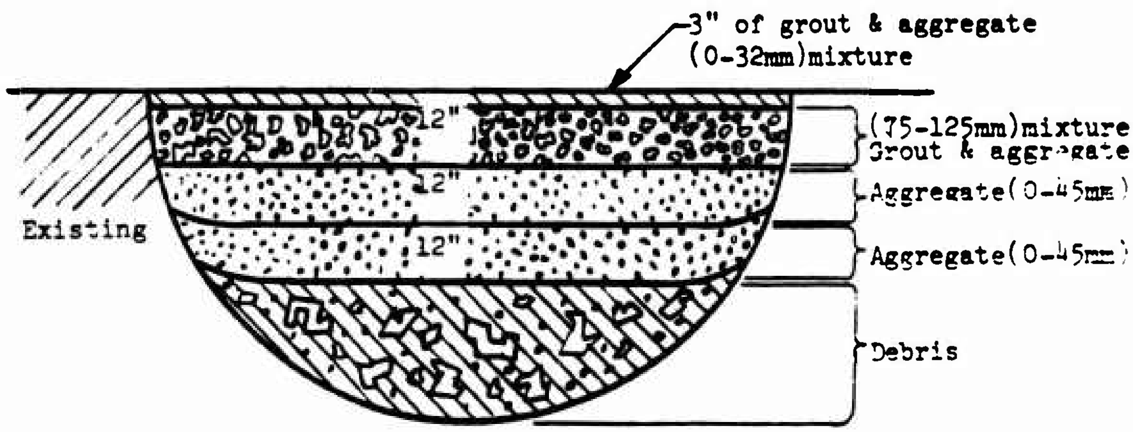


Figure A6. Actual construction of crater

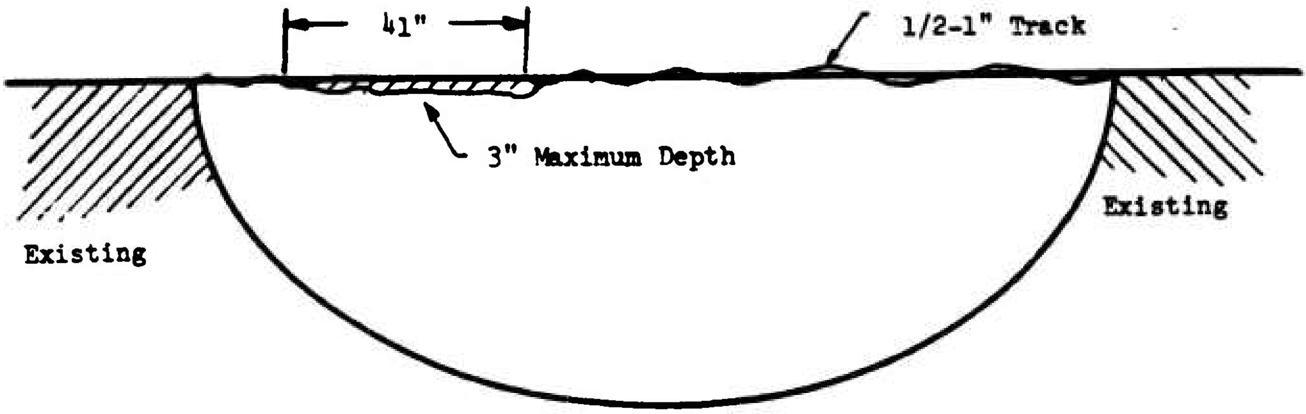


Figure A7. Side view of test strip 2B-1

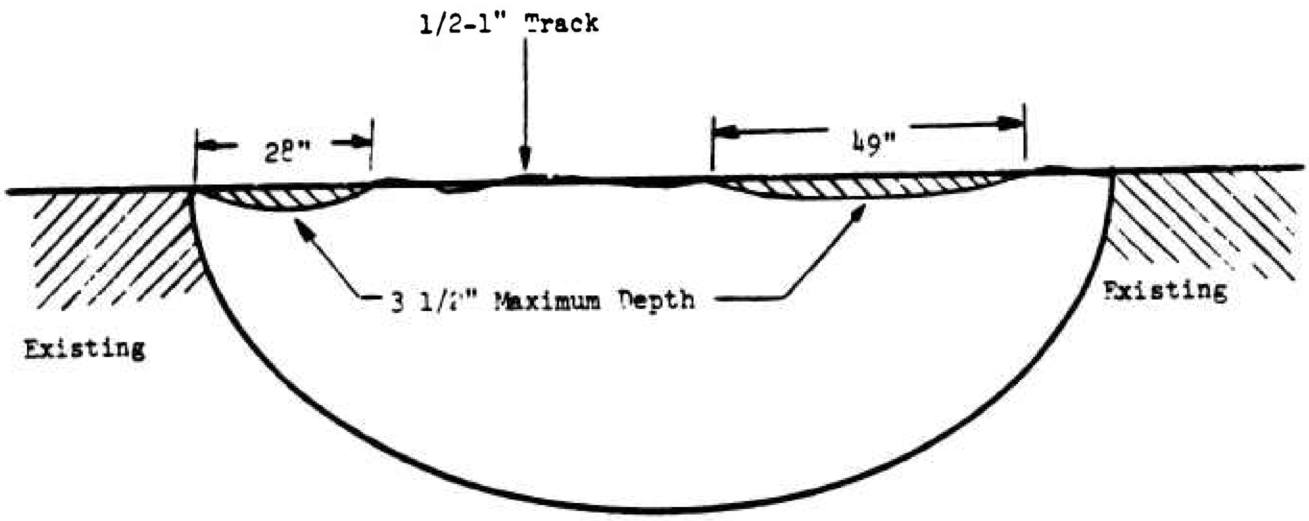


Figure A8. Side view of test strip 2B-2

Photo A1. Placing polyethelene sheet

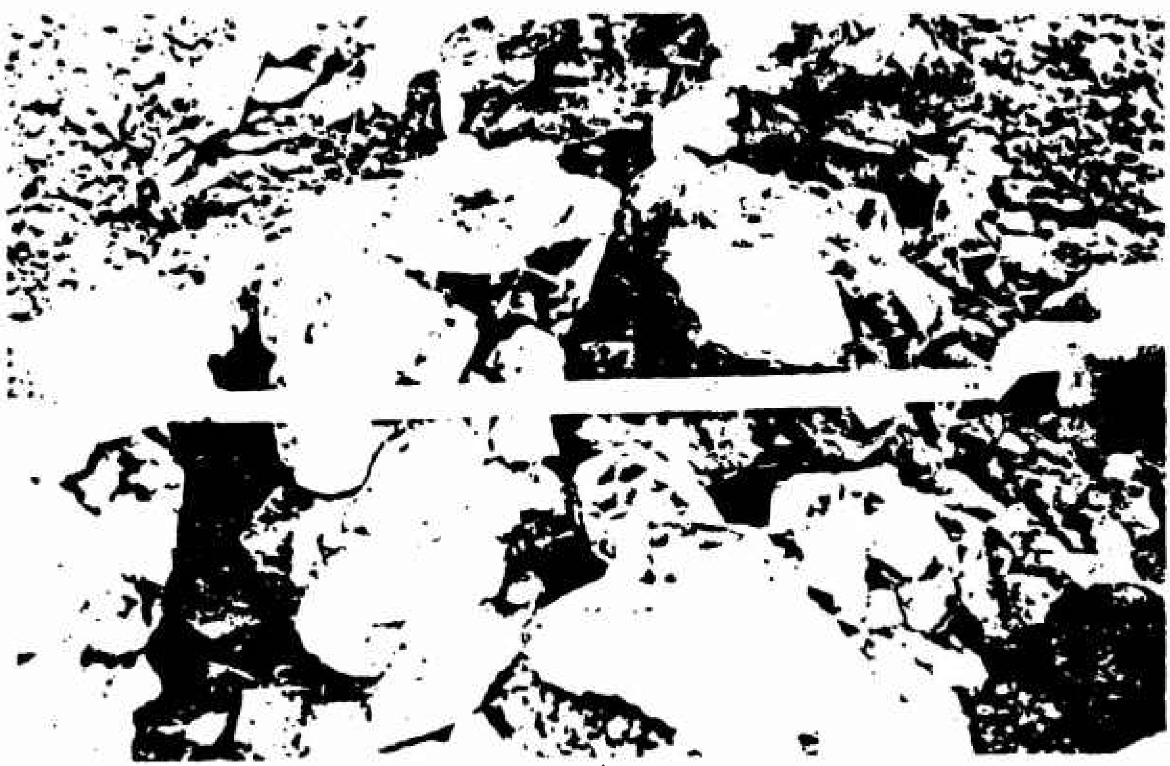


Photo A2. Grout-stone section 69 hr after pour

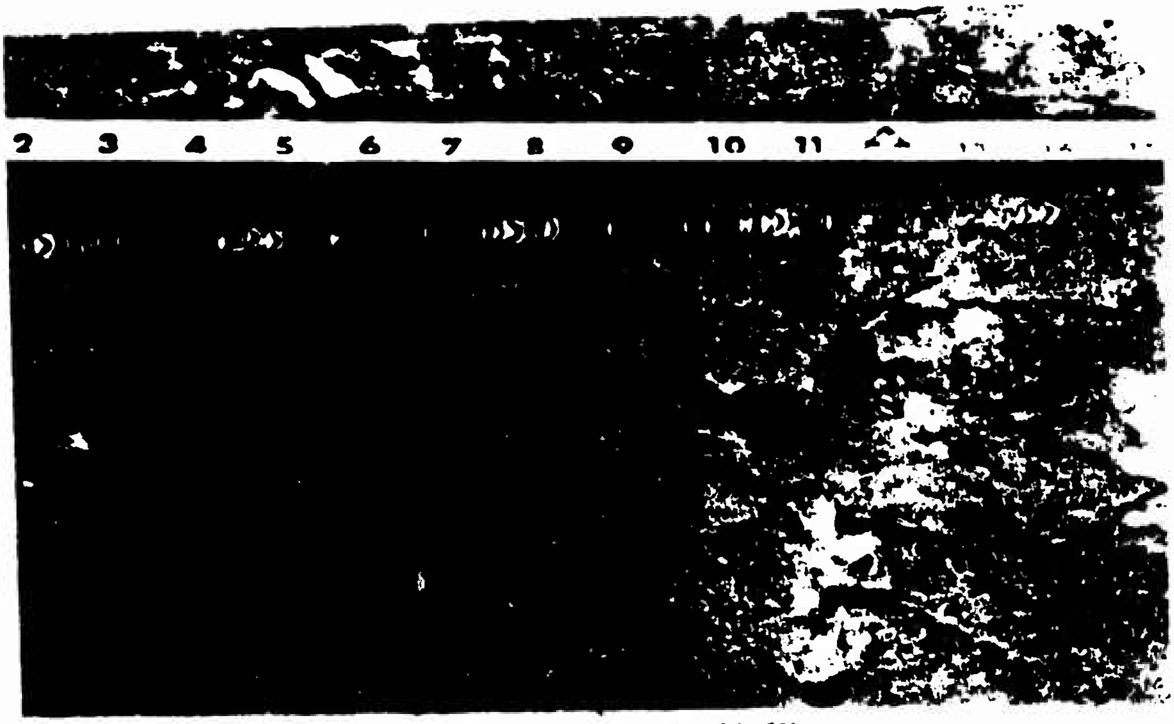


Photo A3. Test strip 1A-1H

Photo A4. Initial grout placement

Photo A5. Continuation of grout placement

Photo A6. Condition of strip 2B-2

Technical Report 81-2-4

Field Test of Large Crater Repair Utilizing Crushed Stone with Sand Blot

Prepared by

CPT Robert M. Devens

Headquarters, 293d Engineer Combat Battalion (HV)

18th Engineer Brigade

APO New York 09034

30 April 1981

CONTENTS

I. Materials

a. Asphalt, petroleum, paving emulsion, rapid setting, DIN 1995, type U60 (NSN: 5610-00-V81-0574) (see DIN 1995, Appendix J). Purchased from:

RAAB KARCHER GMBH

Savigny Str. 5

6000 Frankfurt-1

b. Stone, crushed, aggregate, for road base construction, hardstone, premixed, material and mixture in accordance with "Technical Specifications and Directives of Base Courses in Road Construction (TVT 72), grain size 0-45 mm (NSN: 5610-00-V81-0644) (see Appendix H for Sieve Analysis Data). Purchased from:

HORST KORB, AM Bahnhof 15

6589 Ruschberg, Rheinland-Pfalz

c. Sand, aggregate, river or pit, first blanket, filter larger or filling material, washing, grain size 0-2 mm (NSN: 5610-00-V81-0628). Purchased from:

Director of Engineer/Housing

Baumholder, Germany

APO New York 09034

II. Technique/Procedure: See Technical Evaluation Outline, Appendix E.

III. A Company's Operation

a. Schedule of Events

0906 - Advance Party Arrived

0926 - Main Body Arrived

0942 - Began Clearing Crater

0950 - Began Filling Crater with Debris

1020 - Began Filling Crater with Aggregate

1050 - Began Compaction of Debris

1103 - Continued Filling Crater (Debris Lift not to Proper Height)

1123 - Began Compaction of Debris Lift

1140 - Compaction Test

1145 - Began Filling for First Lift

1215 - Began Compaction of First Lift

1227 - Compaction Test

1233 - Began Filling for Final Lift

1250 - Began Compaction for Final Lift

1301 - Compaction Test

1306 - Cut Excess from Final Lift

1315 - Recompacted Final Lift

1327 - Began Final Cleanup

1335 - Completed Reparation of Crater

b. Problems Encountered: The hauling of the aggregate caused a small delay in the initial filling of the crater.

c. Weather conditions: (3 February 1981)

(1) Wind Direction - 230 deg

(2) Wind Speed - 13 knots (gusts up to 23 knots)

At the time of publication, this page could not be obtained from the author.

At the time of publication, this page could not be obtained from the author.

0734 - Advance Party Arrived (Photo A5)

0756 - Main Body Arrived

0818 - Began Pumping Water from Crater

0820 - Began Clearing Crater

0823 - Began Filling Crater with Debris

0905 - Soft Spot had to be Taken Out

0912 - Refilled Crater

0916 - Began Compaction of Debris

0929 - Compaction Test

0941 - Began Filling Crater for First Lift

1010 - Began Clearing Edge

1021 - Began Compaction of First Lift

1025 - Compaction Test

1016 - Compacted Edges

1045 - Began Filling Crater for Final Lift

1107 - Began Compaction of Final Lift

1115 - Compaction Test

1118 - Cut off Excess Aggregate

1140 - Compated Final Surface

b. Problems Encountered:

(1) The crater had to be pumped out prior to the start of the crater repair. There were 29 in. of standing water.

(2) The debris was saturated, therefore much was removed and replaced by nearby fill with a lower moisture content prior to compacting.

c. **Weather Conditions:** 10 February 1981

Wind Direction - 240 deg

[illegible] Speed - 8 to 10 knots

[illegible]ity - unlimited

Sky Condition - 3,000-ft ceiling

Temperature - high 3°C, low 1°C

d. **Results**

[illegible]T INFORMATION

	Debris	1st Lift	2nd Lift
d	107.01	101.68	112.75
% W	18	18	18
% Compaction	89.18	84.73	94.00

Reading Time/Test - 1 or 2 min Testing Depth - 6 in.

Remarks: The debris was compacted with a 30-ton vibratory roller. The vibrator was not used because the moisture content of the debris was 18% and there were 29 in. of standing water prior to the crater's construction. The required compaction effort of ≥85% CE 55 was achieved. The first lift was compacted with a 30 ton vibratory roller using the vibrator for only one pass. The required compactive effort of ≥95% CE 55 was not achieved. The actual compaction was 10% short of that goal. The final lift was compacted with a 30 ton vibratory roller with the vibrator on. It made 6 passes over the entire lift. The required compaction effort was ≥100% CE 55. An actual compaction

effort of 94% was achieved, 6% short of the standard. The samples were taken in the middle third of the crater. The crater was constructed in accordance with the TEO (Appendix E). The sand blot was placed after testing the crater. It added no strength to the center. The crater was tested 19 hr after its completion.

Test Strip 3B-1 (Figures A6 and A8) completed 50 passes. After nine passes, a track had formed over the length of the strip. After 27 passes, the track depth increased and small amounts of water started percolating up to the surface. After 50 passes, a track 1-2 in. deep had formed. Two large depressions also formed in the track. The maximum depth was 4-1/2 in. Deflections were observed when the test vehicle moved across the crater. Figure A7 shows the actual construction of the crater.

Test Strip 3B-2 (Figures A6 and A9) completed 1 pass. In the middle of the crater, the test vehicle tire sank axle-deep. The only stop to the depression was the intermediate dual axle that stopped the F-4 aircraft tire from sinking deepter. Large amounts of water were observed once the test vehicle was removed. Toward the middle, large deflections (floating) were observed.

Test Strip 3B-3 (Figures A6 and A10) completed 50 passes. After 14 passes, a track had formed over the length of the strip. After 29 passes, the track depth had increased and small amounts of water percolated up to the surface in two areas. After 50 passes, a track 1-2 in. deep had formed. A large depression formed in one area of the track. Its maximum depth was 4 in. Deflections were observed when the test vehicle moved across the crater (Photo A6).

e. Analysis: The track and depressions were caused by the water content in the lifts. The deflections observed as the test vehicle crossed the crater's cap looked like gelatine being placed under a moving point load. The frost helped the cap, but thawed after 27-29 passes. Water started percolating to the surface.

The compactive requirements of the debris lift were achieved only because the debris had a high percentage of gravel in it. The final lift achieved a high compactive effort because a great deal of time was spent achieving it. The 18% moisture content in the lift caused the subcourses to fail.

V. Recommendations:

a. In a crater this size (20 m), the subgrade becomes vitally important. The TEO should have a maximum allowable moisture content requirement included for a normal repair. If over that standard, soil reinforcement techniques are required.

b. The TEO needs to have a contingent technique stating that if there is standing water, aggregate (75-175 mm) is required to be mixed with the debris to help stabilize the soil. The debris in these repairs was from old crater subgrades, and therefore had a high percentage of aggregate (0-56) already mixed in.

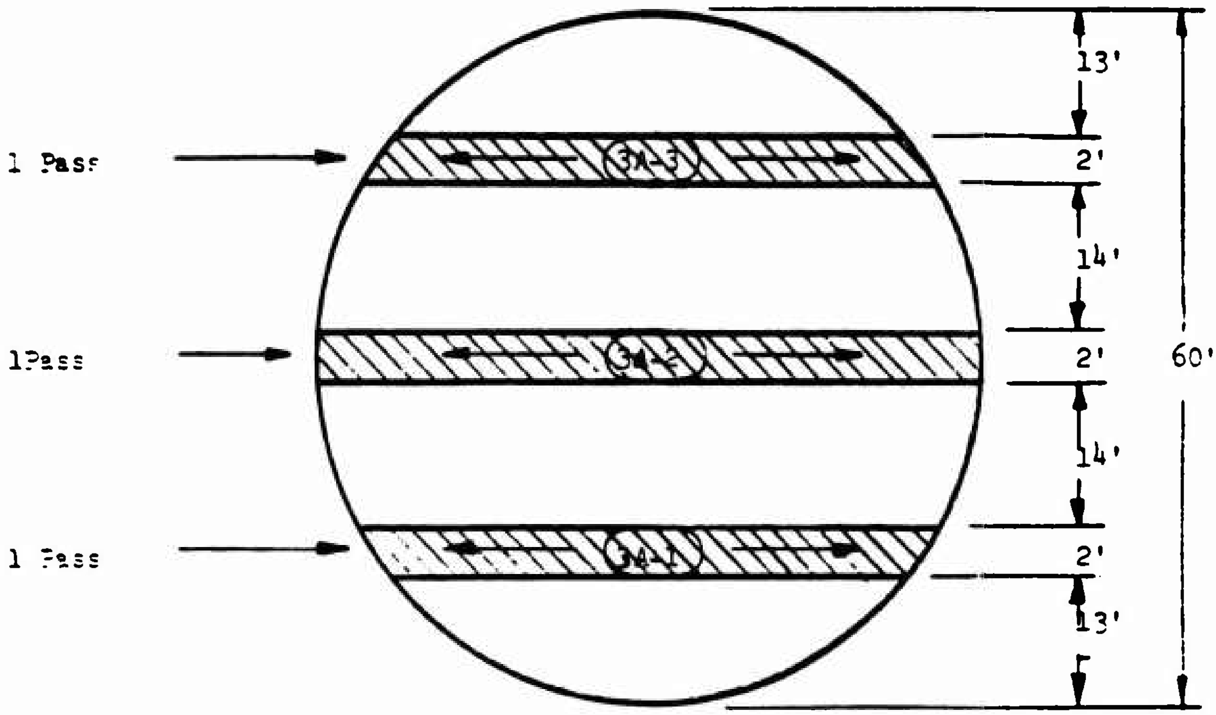


Figure A1. Top view of crater after test

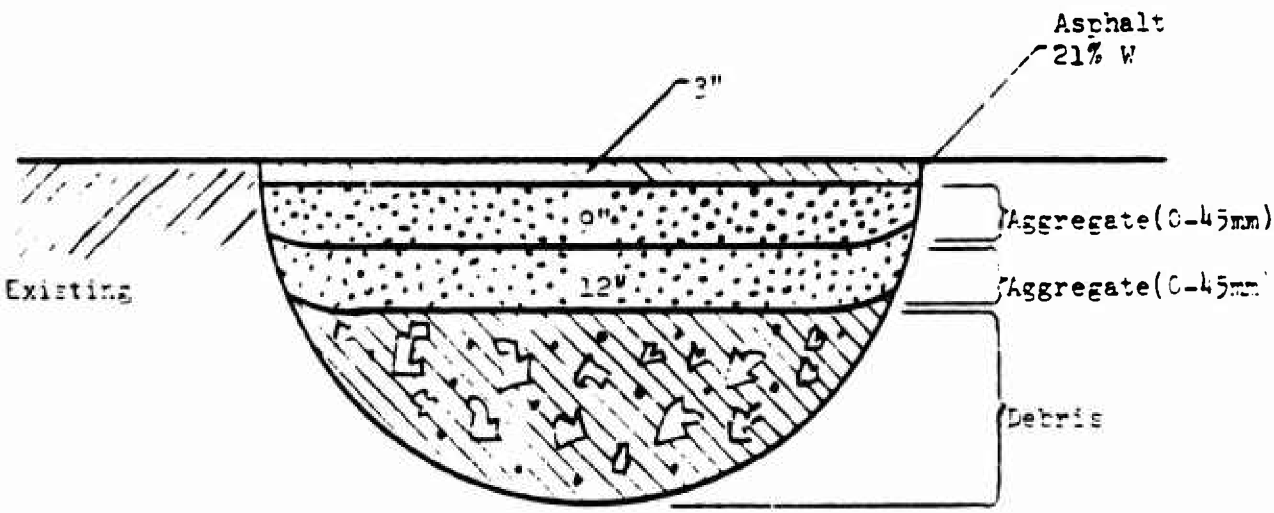


Figure A2. Actual construction of crater

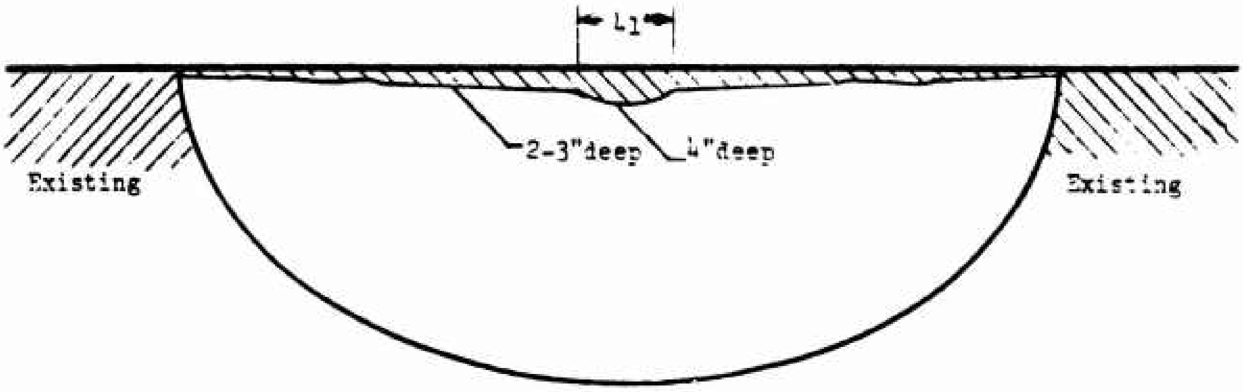


Figure A3. Side view of test strip 3A-1

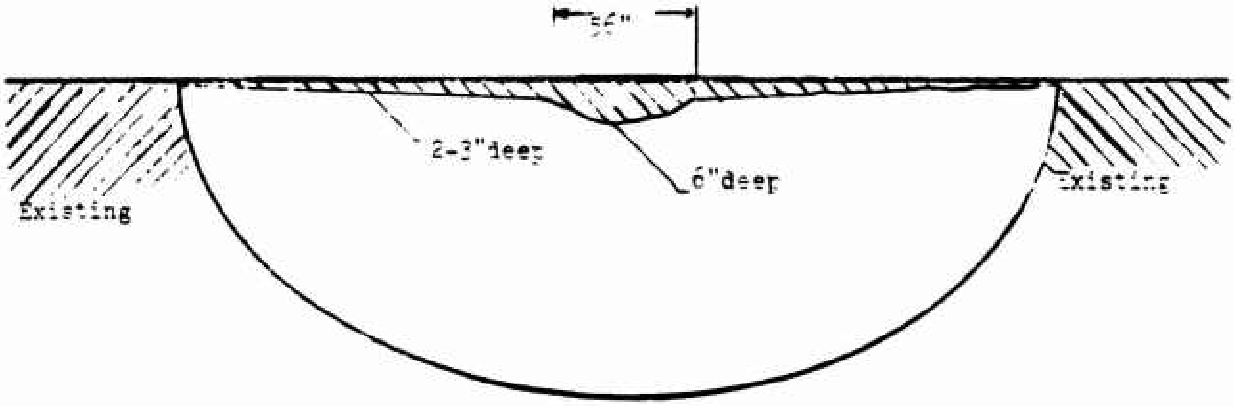


Figure A4. Side view of test strip 3A-2

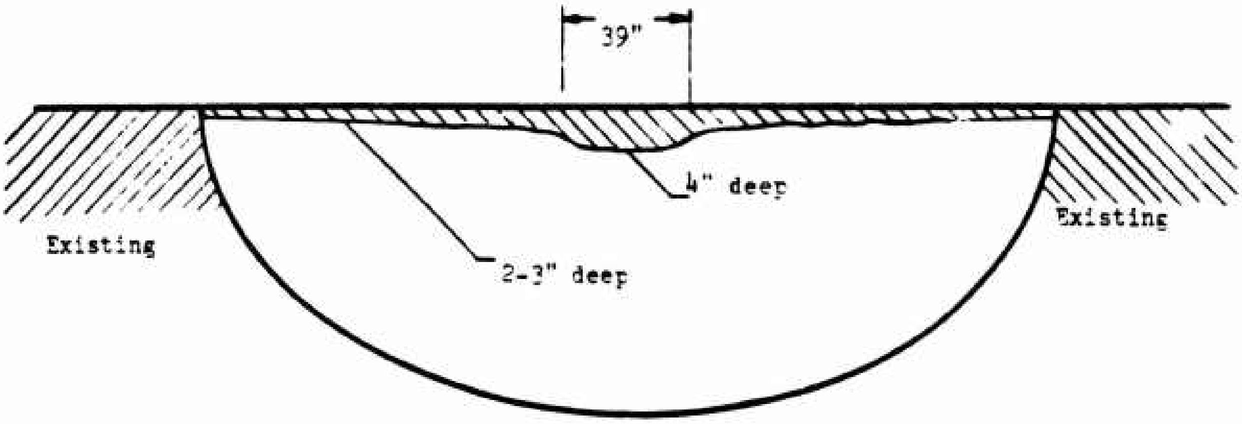


Figure A5. Side view of test strip 3A-3

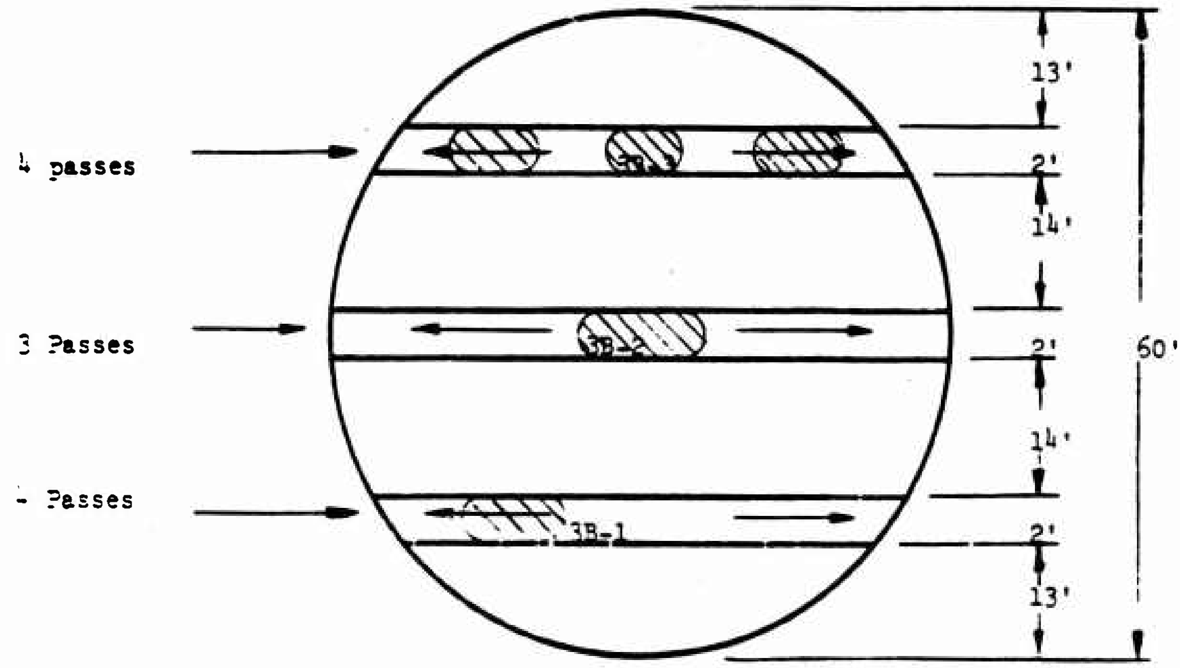


Figure A6. Top of crater after test

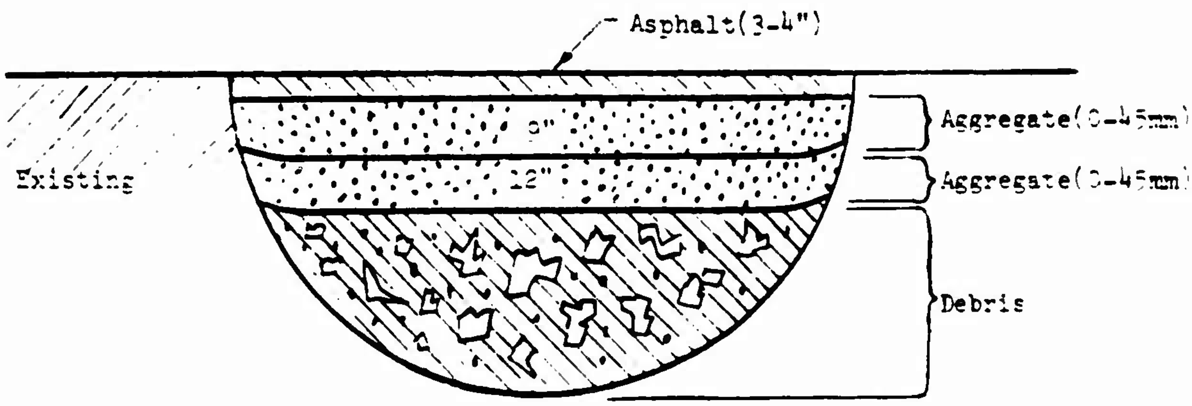


Figure A7. Actual construction of crater

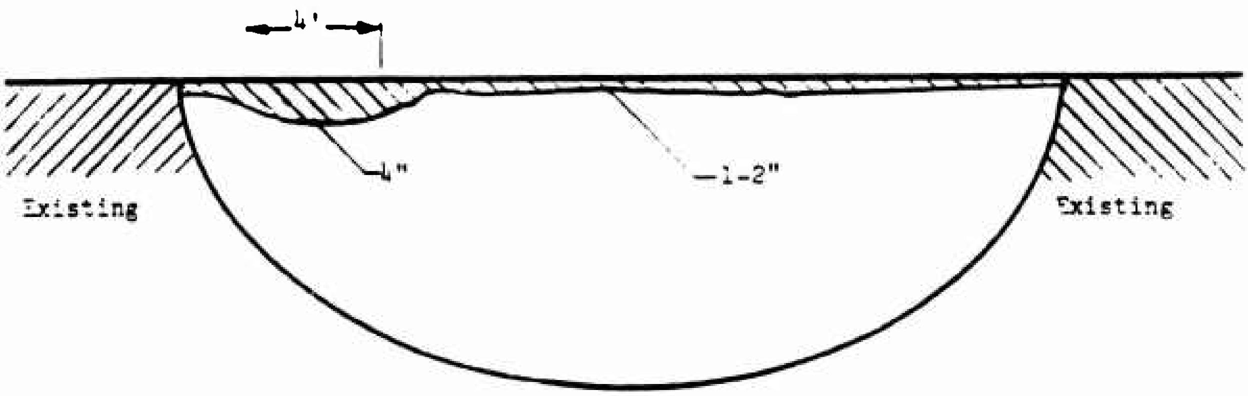


Figure A8. Side view of test strip 3B-1

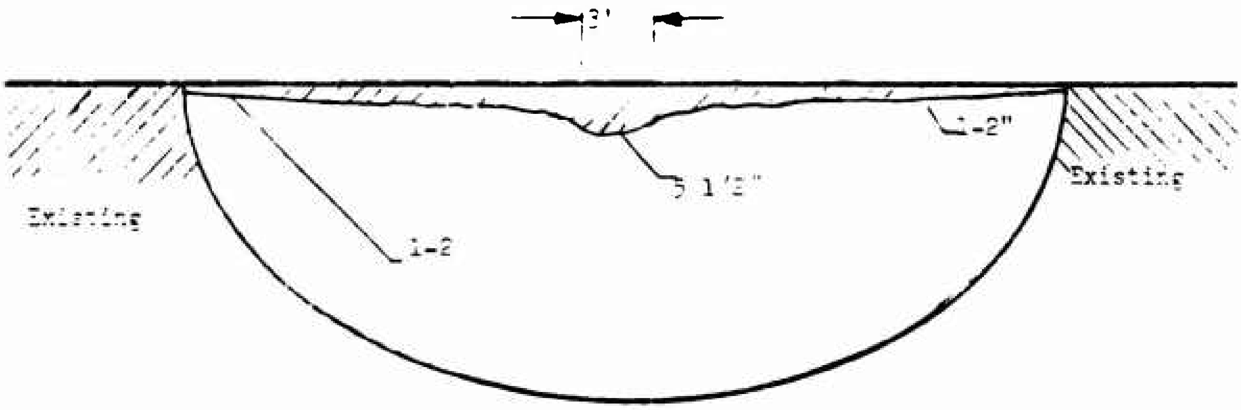


Figure A9. Side view of test strip 3B-2

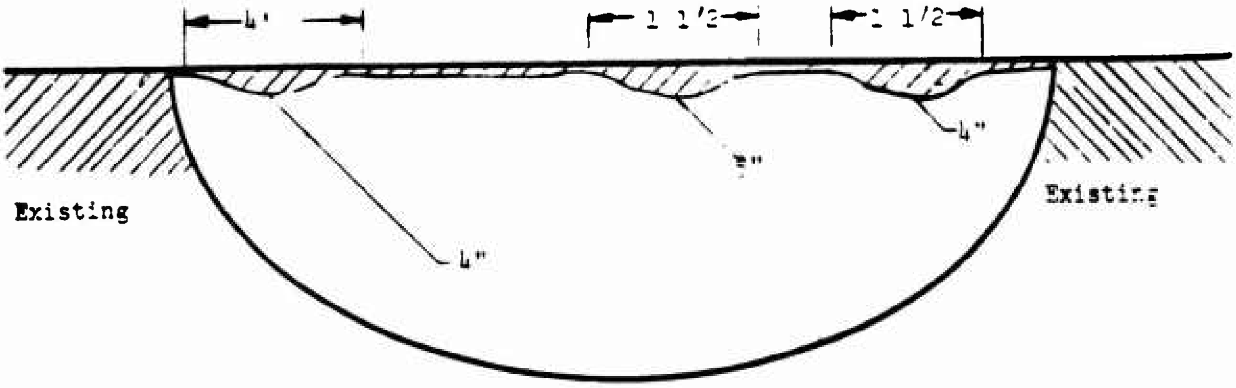


Figure A10. Side view of test strip 3B-3

Photo A1. Blending aggregate for cold mixing

Photo A2. Windrowing aggregate for asphalt cold mix

Photo A3. Rutting in cold asphalt

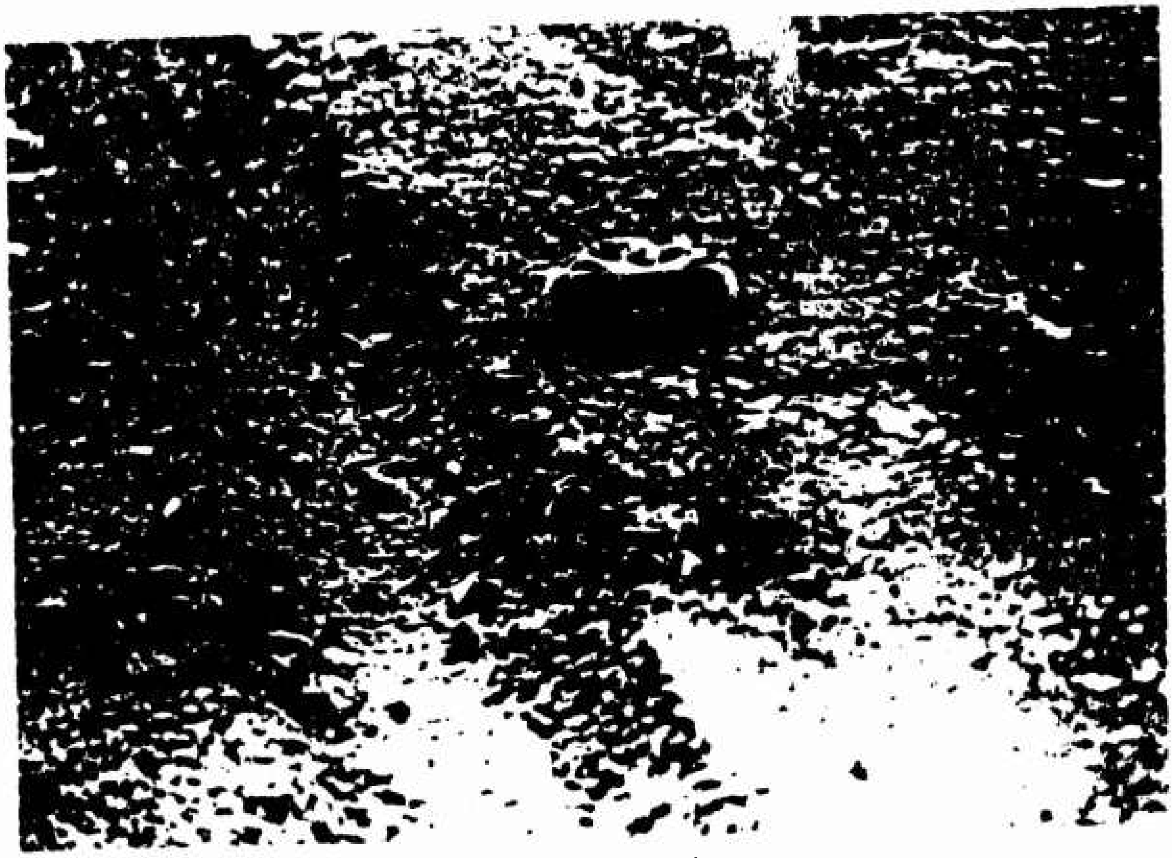


Photo A4. Rutting

Photo A5. Initial site arrival

Photo A6. Severe rutting due to low strength

Technical Report 81-2-5

Field Test of Large Crater Repair Utilizing Cold Asphalt Road Mix

Prepared by

CPT Robert M. Devens

Headquarters, 293d Engineer Combat Battalion (HV)

18th Engineer Brigade

APO New York 09034

30 April 1981

Contents

I. Materials

a. Asphalt, petroleum, paving emulsion, rapid setting, DIN 1995, type U60 (NSN: 5610-00-V81-0574) (see DIN 1995, Appendix J). Item a was purchased from:

RAAB KARCHER GMBH

Savigny Str. 5

6000 Frankfurt-1

b. Stone, crushed, aggregate, for road base construction, hardstone, premixed, material and mixture in accordance with "Technical Specifications and Directives for Construction of Road Base Underwearing Courses (TVT)", grain size 0-32 mm (NSN: 5610-00-V81-0644). See Appendix H for sieve analysis data.

c. Stone, crushed, aggregate, for road construction, base course material, hardstone, ready mixed, material and mixture in accordance with "Technical Specifications and Directives for Execution of Base Courses in Road Construction TVT 72", grain size 0-45 mm (NSN: 5610-00-V52-0130). See Appendix H for sieve analysis data.

The above items b and c were purchased from:

HORST KORB, Am Bahnhof 15

6589 Ruschberg, Rheinland-Pfalz

II. Technique/Procedure: See Technical Evaluation Outline, Appendix F.

III. A Company's Operation

0730 - Advance Party Arrived

0743 - Main Body Arrived

0800 - Began Filling Crater with Debris

0809 - Cleared Crater Edge

0845 - Compacted Debris

0905 - Compaction Test

0908 - Began Filling Crater with Aggregate for 1st Lift

0932 - Fixed Up Asphalt Truck

0933 - Compacted Final Lift

0941 - Compaction Test

0944 - Recompacted First Lift

1000 - Compaction Test

1002 - Began Filling Crater with Aggregate for 2nd Lift

1031 - Compacted 2nd Lift

1031 - Began spreading Aggregate on Runway for Asphalt Cold Mixing Procedure (Photo A1)

1055 - Cleared Crater Edge

1140 - Cut Lift to Final Grade

1200 - Compacted 2nd Lift

1203 - Compaction Test

1213 - Compacted Edge

1243 - Cleaned Edge

1252 - Recompacted 2nd Lift

1318 - Placed Tack Coat on 2nd Lift

1323 - Began Asphalt Cold Mix Procedure

1330 - Began Capping Crater with Asphalt Cold Mix

1505 - Graded Cap of Crater

1522 - Compacted Cap

1536 - Completed Crater

b. Problems Encountered:

(1) The spreading out of the aggregate across the runway for the cold mix procedures caused vehicle congestion around the crater, resulting in a 10-min delay.

(2) The inexperience of the vehicle operators with the asphalt cold mix procedures caused minor delays.

(3) The high moisture content of the air (and rain itself) increased the time it took to mix the asphalt in the aggregate. This caused about 10 min delays since more aggregate turnovers were required.

c. Weather Conditions: 4 February 1981

(1) Wind Direction - 250 deg

(2) Wind Speed - 6 knots (with gusts)

(3) Visibility - 3 miles (rain and snow)

(4) Sky Condition - 1,000-ft ceiling

(5) Temperature - 1°C (with chill factor -1°C)

d. Results:

Lift Information

Test	Debris	1st Lift	2nd Lift
d	100.32	104.28	110.00
% W	12	12	12
% Compaction	80.0	83.0	88.0

Reading Time/Test - 1 or 2 min   Testing Depth - 6 in.

Remarks: The debris was compacted with a 30-ton vibratory roller. The required compaction effort was ≥85% CE 55. The actual compaction effort achieved was 80%, 5% short of the standard. The final lift was compacted with a 30-ton vibratory roller, and achieved a compaction effort of 83%, 12% short of the ≥95% CE 55 compactive effort standard. The final lift was compacted with a 30-ton vibratory roller. A compactive effort of 88% CE 55 was achieved, 12% short of the ≥100% standard. The asphalt cold road mix was completed by spreading the aggregate out in a 3-4 in. lift over a large area using a grader. The new organic bituminous mixer then distributed the asphalt as specified. The grader mixed the aggregate and set it out again for more passes of the bituminous truck. The mix was then picked up and placed in the crater with a 5-cu yd front loader. The asphalt lift was then compacted using a 30-ton vibratory roller without the vibrator turned on. The 3-in. asphalt lift could not be tested using the nuclear densometer. The tests were taken in the middle third of the crater. The crater was completed in accordance with the TEO except for the asphalt layer. The final aggregate lift was 4-5 in. rather than the 3-in. standard. The crater after being filled with asphalt mix and compacted, was low compared to the existing surface. The crater was tested 19 hr after its completion

Test Strip 4A-1 (Figures A1 and A3) completed 1 pass. On the first pass, the test vehicle pressed a 2-3 in. track across the entire length of the test strip. In the middle of the crater, the asphalt gave way and the vehicle formed a depression with a maximum depth of 4 in. Deflections were observed. No cracks were observed. Figure A2 shows the actual construction of the crater.

Test Strip 4A-2 (Figures A1 and A4) completed 1 pass. On the first pass, the test vehicle pressed a 2-3 in. track across the entire length of the test strip. In the middle of the crater, the asphalt gave way and a depression with a depth of 6 in. formed. Deflections were observed. No cracks were observed.

Test Strip 4A-3 (Figures A1 and A5) completed 1 pass. On the first pass, the test vehicle pressed a 2-3 in. track across the entire length of the test strip. In the middle of the crater, the asphalt gave way and a depression with a depth of 4 in. formed. Deflections were observed. No cracks were observed.

e. Analysis: The subgrade did not achieve the compactive effort standards, therefore, the deflections occurred while the test vehicle crossed the crater. The moisture content of the subgrade was 12 percent. The aggregate used in the cold mix had a moisture content of 21%. It was raining and snowing at the time. The temperature of the aggregate was 1°C. The asphalt (U60) was just coating the water on the aggregate. The asphalt cooled down immediately and was cold by the time the mixing procedure started. The asphalt did not bind and therefore failed under the weight of the test vehicle. The procedure of spreading the asphalt over a large area made the aggregate more vulnerable to the weather conditions, and caused a hindrance for it congested the area for vehicle operation.

III. B. Company's Operation

a. Schedule of Events

0730 - Advanced Party Arrived

0745 - Main Body Arrived

0800 - Began Filling Crater with Debris

0809 - Cleaned Crater Edge

0845 - Compacted Debris

0855 - Compaction Test

0908 - Began Filling Crater with Aggregate for 1st Lift

0932 - Fixed Up Asphalt Truck

0932 - Compacted 1st Lift

0941 - Compaction Test

0944 - Recompacted 1st Lift

1000 - Compaction test

1002 - Began Filling Crater with Aggregate for 2nd Lift

1031 - Compacted 2nd Lift

1031 - Began Windrowing Aggregate for Asphalt Cold Mix Procedure (Photo A2)

1055 - Cleaned Crater Edge

1140 - Cut Lift Below Grade Level for Asphalt Cap

1200 - Compacted 2nd Lift

1213 - Cleaned Crater Edge

1318 - Placed Tack Coat on 2nd Lift

1323 - Began Asphalt Cold Mix Procedure

1330 - Began to Place Asphalt Cap

1505 - Graded Asphalt Cap

1522 - Compacted Asphalt Cap

1536 - Completed Crater

b. Problems Encountered:

(1) A pump had to be set up to remove 9 in. of standing water.

(2) The mixing procedure was slow because the rock was wet and cold, the asphalt would not coat the aggregate properly.

(3) The windrawing method of mixing the cold road mix was new to the equipment operators. After two runs, the operators increased their efficiency. Only 10 min were lost.

c. Weather Conditions: 11 February 1981

Wind Direction - 360 degrees

Wind Speed - 4 knots

Visibility - 5 miles (unlimited)

Sky condition - 3,500-ft ceiling

Temperature - (5°C high/0°C low)

d. Results:

LIFT INFORMATION

	Debris	1st Lift	2nd Lift
d	109.62	108.78	107.52
% W	16	16	16
% Compaction	87.70	87.02	867.02

Remarks: The debris was compacted with a 30-ton vibratory roller. The required compactive effort of ≥85% CE 55, was achieved. The first lift was compacted with a 3.-ton vibratory roller, and achieved a compactive effort of

87%, 8% short of the ≥95% CE 55 compactive effort standard. The first lift was compacted with a 30-ton vibratory roller. A compactive effort of 86% CE 55 was achieved, 14% short of the ≥100% standard. The asphalt cold road mix was completed by forming a windrow and then taking just enough rock from it to make a lift 3-4 in. deep and the width of the bituminous truck. This was done with a grader. The bituminous trucks then distributed the asphalt. The grader pushed this material over, mixing the asphalt with the rock at the same time forming another lift parallel to the windrow but closer to the crater. The bituminous truck then placed another coat of asphalt. The grader rolled the rock, mixing it and pushing it close to the crater. The mixture was then placed in the crater using the 5-cu yd front loader. The 3-in. asphalt lift could not be tested with the nuclear densitometer. The asphalt lift was compacted with a vibratory roller. All tests were taken in the middle third of the center. The crater was completed in accordance with the TEO (Appendix F). The crater was tested 18 hr later during the next morning. The outside temperature was 42°F/6°C but the temperature between the asphalt and aggregate layer (3-5 in. below the surface) was 26°F/3°C.

Test Strip 4B-1 (Figures A6 and A8) completed 4 passes. After 4 passes, a track 1-2 in. deep was made across the entire length of the strip. At one end, a depression 4 ft long with a max depth of 4 in. formed. Deflections were observed. No cracks were observed. Figure A7 shows the actual construction of the crater.

Test Strip 4B-2 (Figures A6 and A9) completed 3 passes. After 3 passes a track 1-2 in. deep was made across the entire length of the test strip. In the middle of the crater, a depression 3 ft long with a maximum depth of 5-1/2

in. formed. Deflections were observed. No cracks were observed.

Test Strip 4B-3 (Figures A6 and A10) completed 4 passes. After 3 passes, a track 1-2 in. deep was made across the entire length of the test strip. At these locations along the strip, depressions formed. The first was 4 ft long with a maximum depth of 4 in. The second was 1-1/2 ft long with a maximum depth of 5 in. The third depression was 1-1/2 ft long with a maximum depth of 4 in. Deflections were observed. No cracks were observed.

e. Analysis: The subgrade did not achieve the compactive standards; therefore, the deflections occurred while the vehicle crossed the crater. The moisture content of the subgrade was 16%. The aggregate used in the cold mix had a moisture content of 19%. The aggregate was wet since it was not protected from the environment. The temperature of the aggregate was 4°C. The asphalt (U60) covered the water-coated aggregate. The asphalt cooled down too rapidly and was cold prior to the finish of the cold mixing procedure. The asphalt coated aggregate would not bind because of the water; therefore under the weight of the test vehicle, the center failed. The windrow procedure worked very effectively but the rock was still exposed to the inclement weather conditions.

V. Recommendations:

a. The asphalt repair did not work under the inclement weather conditions. If used as a repair technique, two requirements need to be enforced. As stated in the TEO, the moisture content of the aggregate cannot be greater than 3%. The second requirement which would have to be added to the

TEO is that the outside temperature must be above 40°F/4.4°C.

b. The asphalt cap in this repair is flexible and therefore dependent upon the subgrade. The compaction effort standards in the TEO must be met when using this technique.

c. The windrow procedure for mixing the asphalt and stone should be adopted and standardized for training purposes. It took less vehicles, was faster, and used the least amount of space on the runway. The technique of spreading the rock out over a large area caused vehicle congestion and took longer.

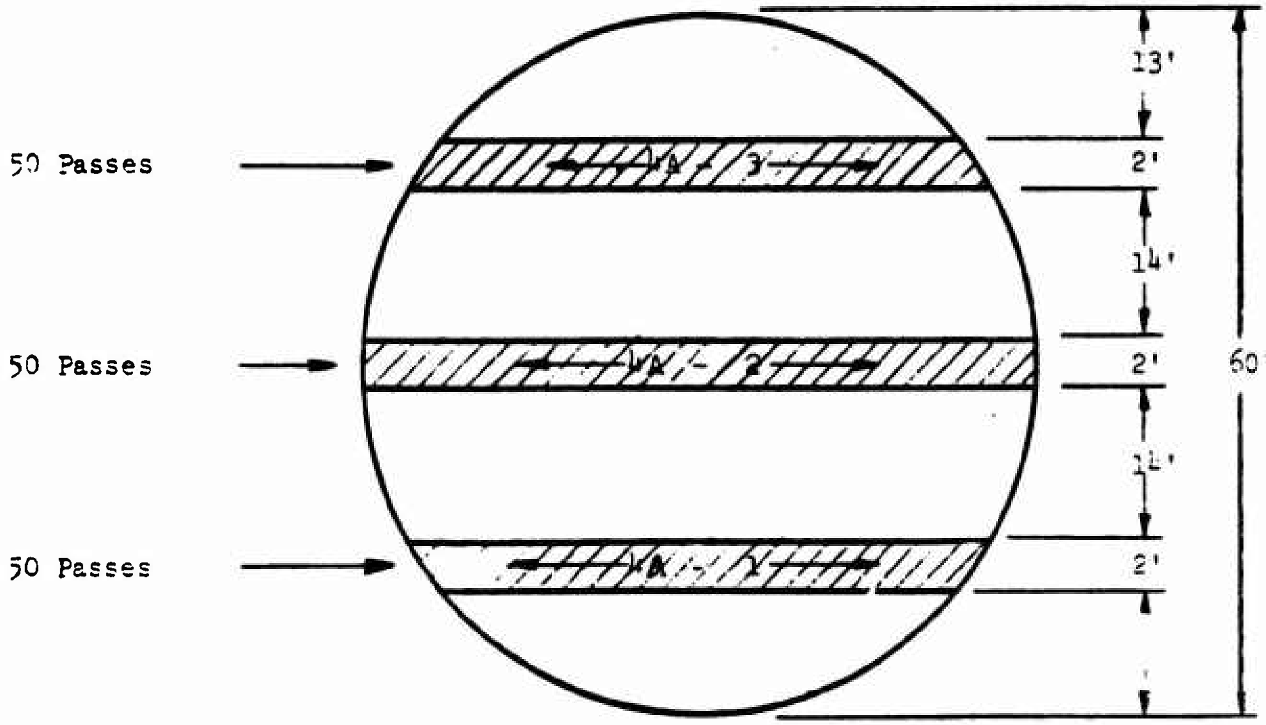


Figure A1. Top view of crater after test

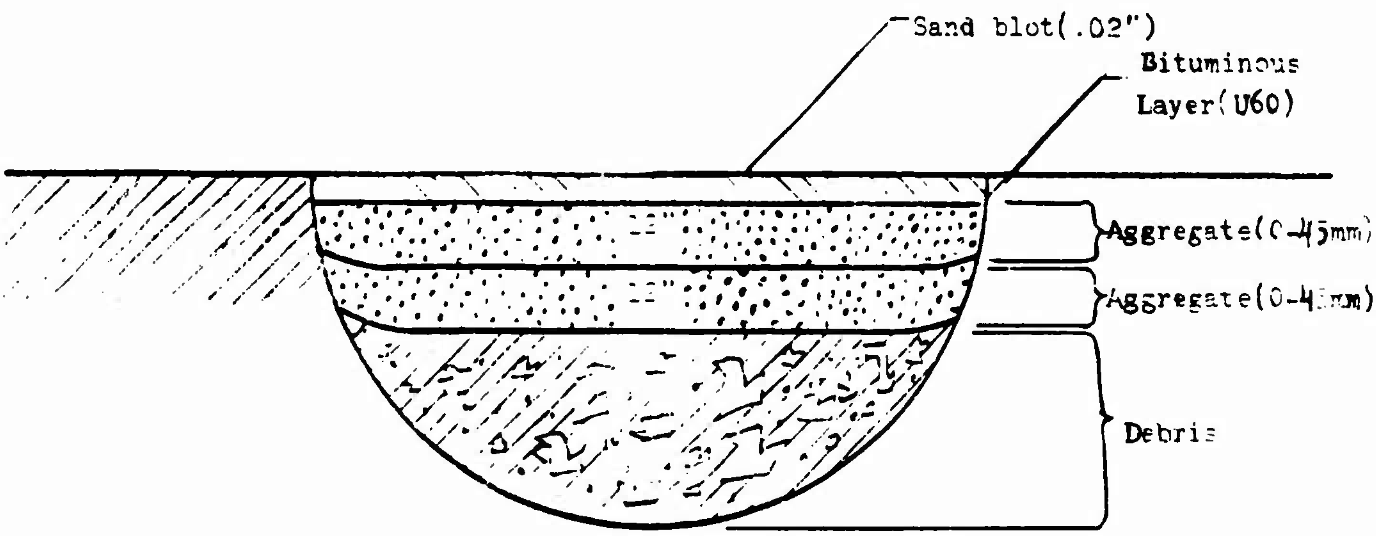


Figure A2. Actual construction of crater

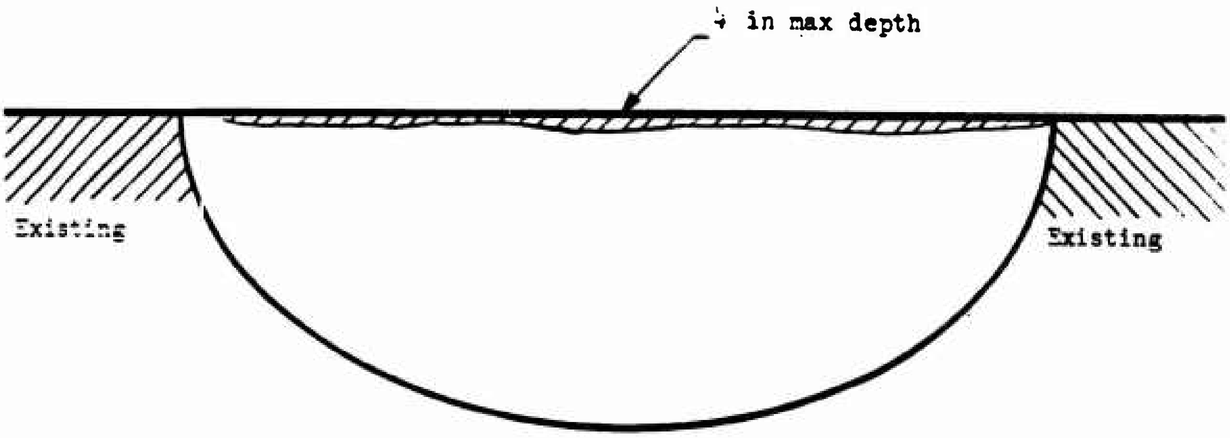


Figure A3. Side view of test strip 4A-1

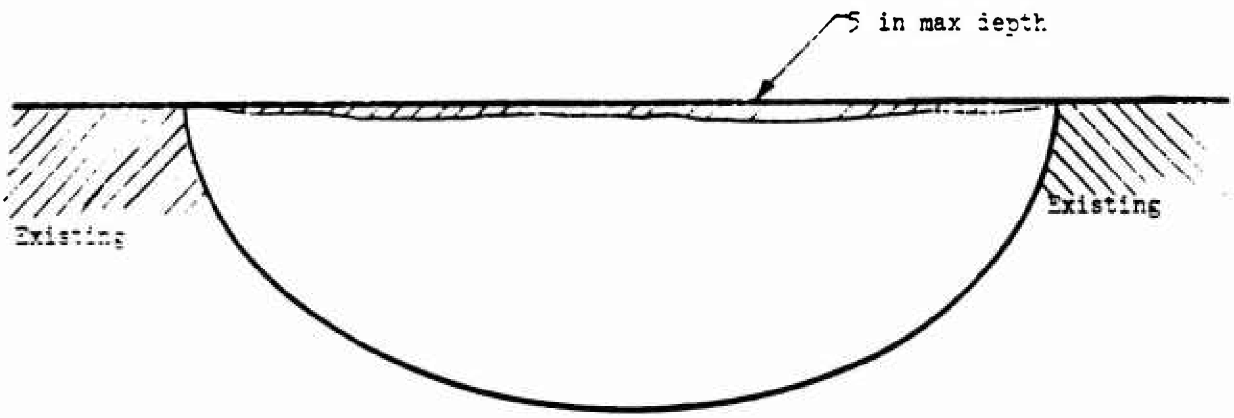


Figure A4. Side view of test strip 4A-2

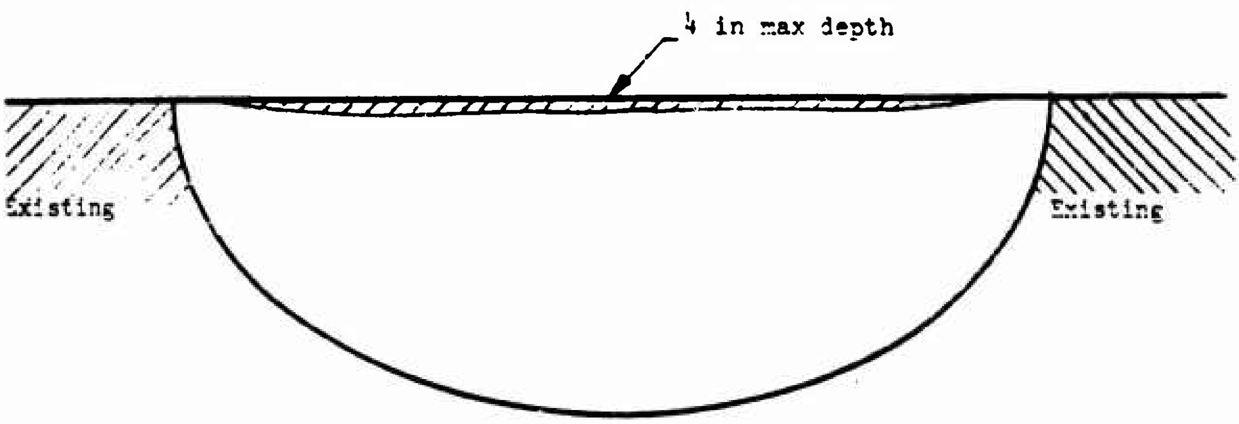


Figure A5. Side view of test strip 4A-3

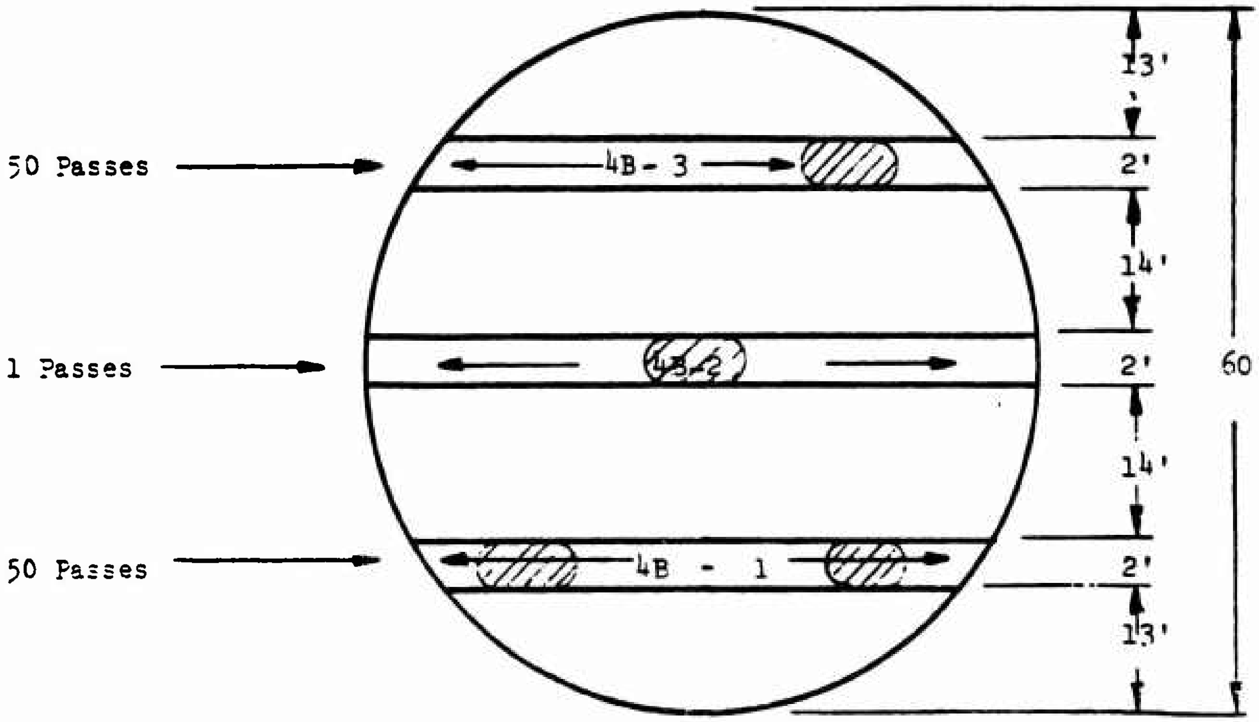


Figure A6. Top view of crater after test

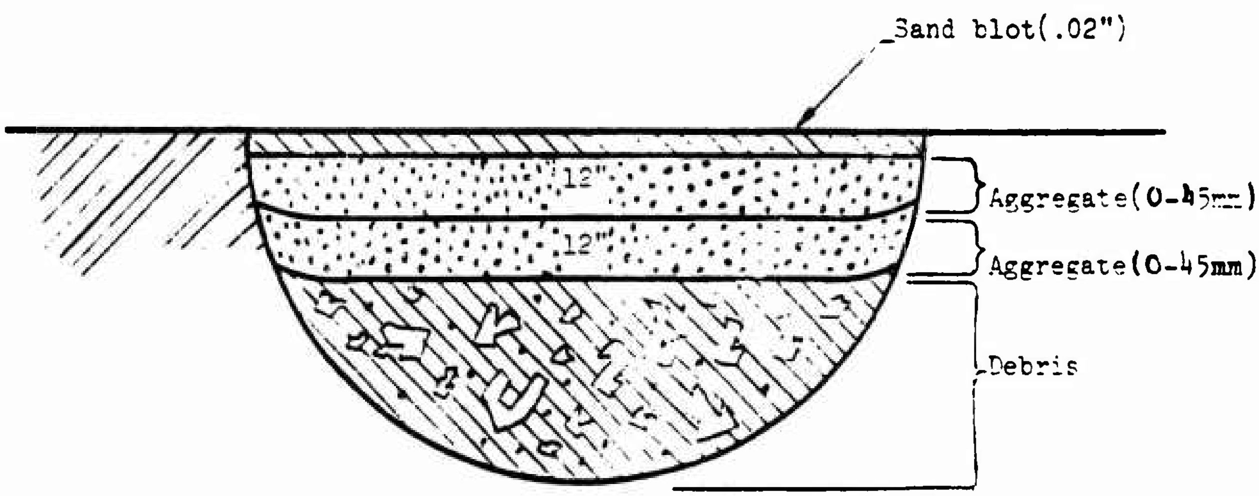


Figure A7. Actual construction of crater

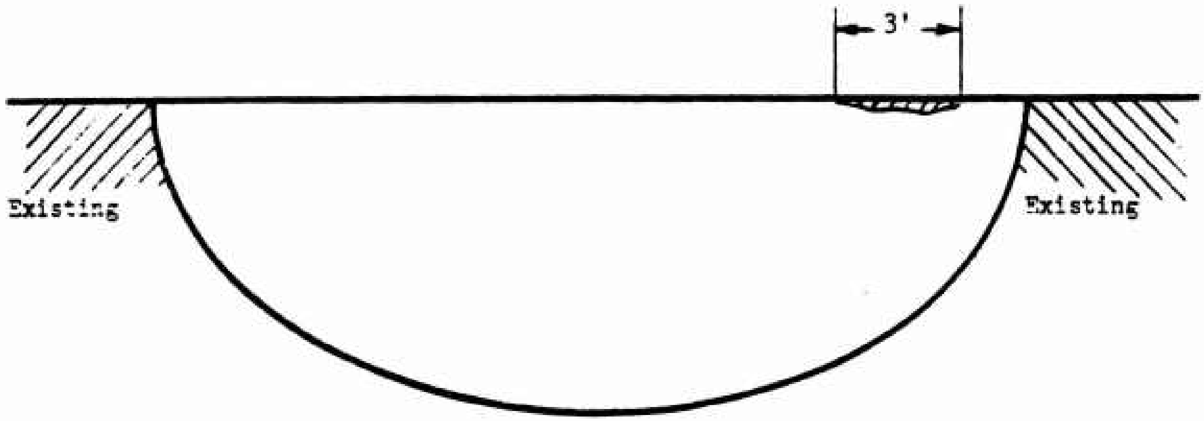


Figure A8. Side view of test strip 4B-1

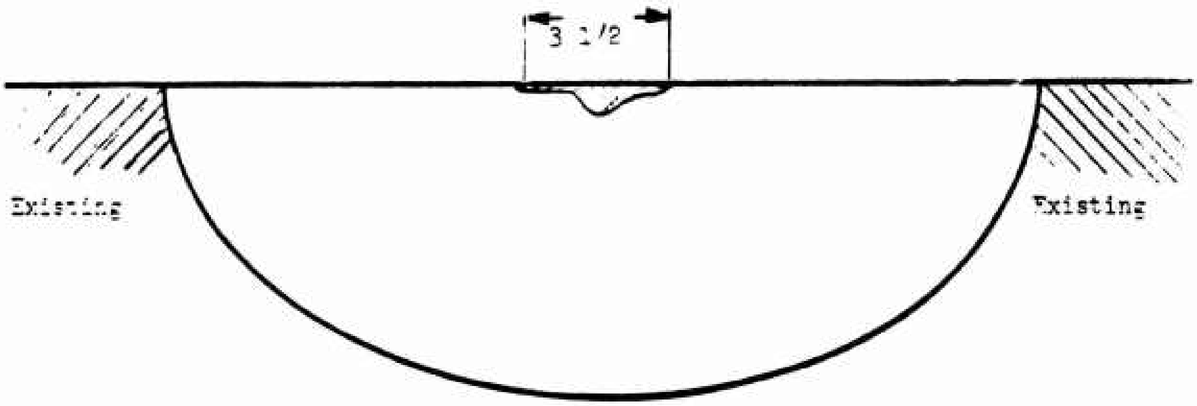


Figure A9. Side view of test strip 4B-2

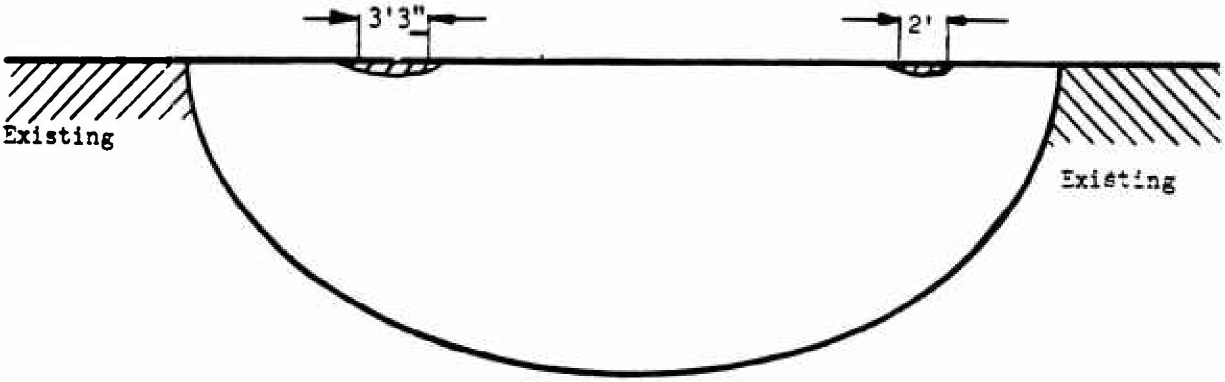


Figure A10. Side view of test strip 4B-3

Photo A1. Blending aggregate for cold mixing

Photo A2. Windrowing aggregate for asphalt cold mix

Technical Report 81-2-6

Field Test of Spall Repairs Utilizing Silikal Powder and Liquid

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30 April 1981

Contents

I. Materials

a. Synthetic resin, acryl, dig, free of solvents for production of mortar for concrete repairs, 2 component material, consisting of:

(1) Component 1: powder with quartz sand addition, grain size up to 1.5 mm, in fact lined kraft paper bag of 15 KG.

(2) Component 2: liquid hardner in 2-ℓ can.

Color of ready mixed mortar: stone-grey RAL 7030, brand name: SILIKAL (see Appendix M for additional information). The silikal was purchased from:

KARL ULRICH & CO KG

Chemishce Erzeugnisse

Ostring 23

6451 Mainhausen 1

II. Technique/Procedure: (See Technical Evaluation Outline, Appendix G).

III. A Company Operation

a. Construction Sequence

1000 - Cleaned out Spall

1005 - Dryed out Spall

1022 - Mixed Silikal

1024 - Placed Silikal

1040 - Finished 1st Spall

- 7 Spalls were Completed at Varying Times during the Day

b. Problems Encountered: No problems were encountered with the spall repair.

c. Weather Conditions: 3 February 1981

(1) Wind Direction - 230 deg

(2) Wind Speed - 13 knots (gusts to 23 knots)

(3) Visibility - 2 miles (rain and snow with fog)

(4) Sky Condition - obscure (cloud cover at 1,500 ft)

(5) Temperature - 0°C (with chill factor -17°C)

d. Results: The silikal was very effective. It hardened in about 45 min. After that time, a 160-lb man could walk across it. The constant shower of rain made it impossible to keep the walls of the spall completely dry so there was water on all sides. Once the silikal was completely dry (21 hr, when a person stepped on the spall, water would come up from the edges. The spalls did withstand a pass from the test vehicle with no failures except for a small amount of edging which cracked off. See Photo A1 for illustration.

Analysis: The silikal was excellent because of its fast hardening properties. For example, this was ideal for minimum manpower was necessary. The spall repair separated due to the water and oil residue on its walls. The rigid wall surface held the repair in place but did move downward under pressure. The movement was minute (1/64 in.) because of the water. The lips of the repair broke off since the existing pavement left only 1/2 in. for the repair. The repair came up easily with a 80-lb jack hammer using a star bit. The rigid edges of the spalls did not provide enough hold for a permanent repair. The hold varied from spall to spall. See Photo A2 for illustration.

IV. B Company Operation

a. Construction Sequence

0850 - Cleaned out Spalls

0920 - Dryed out Spalls

0945 - Laid out Silikal Material

1005 - Mixed Silikal

1007 - Placed Silikal

1022 - Finished 1st Spall

1046 - Mixed Silikal

1049 - Placed Silikal

1057 - Finished 2nd Spall

1510 - Mixed Silikal

1512 - Placed Silikal

1525 - Finished 3rd Spall

b. Problems Encountered: No problems were encountered with the spall repairs.

c. Weather Conditions: 9 February 1981

(1) Wind Direction - 170 deg (variable)

(2) Wind Speed - 3 knots

(3) Visibility - Unlimited

(4) Sky Condition - 3,500-ft ceiling

(5) Temperature - 4°C (low)/8°C (high)

d. Results: Gasoline was placed in the spall and set afire to dry it rather than using a blow torch. This provided better drying and left no diesel residue behind on the walls of the spall. The spall repair was excellent. Under pressure no water came up through the joints. Along the lip of the repair where the depth was less than 1/2 in., the repair cracked off. This would cause foreign object damage to aircraft. No deflections were observed.

e. Analysis: The silikal with its fast setting properties and fast preparation procedure provided a rapid means to repair spalls. The gasoline used left a small amount of carbon residue behind which did not affect the surfaces of the spalls. The rigid wall surfaces held the repair in place. The repairs did not move under pressure. The repair's edge broke off because the spall left only one half of an inch for the repair.

V. Recommendations: The spall repair using silikal was expensive but could be performed using two personnel per spall. No additional equipment except for a hand float was required. The repairs using the gasoline set afire rather than the blow torch left no diesel residue behind to decrease the binding of the old surface and the new repair. Two additional subtasks should be added to the spall repair technique. To prevent the cracking of the new repair, the uneven edges should be taken off with a mason's hammer. If not performed, the broken pieces would result in foreign objeet damage to aircraft.

To make the spall repair permanent, a method of securing the spall to the existing surface is required. Relying on the edges of the spalls is uncertain. Using sheet metal straps secured with ramset nails to the existing spall walls is a solution. Figure A1 illustrates this technique.

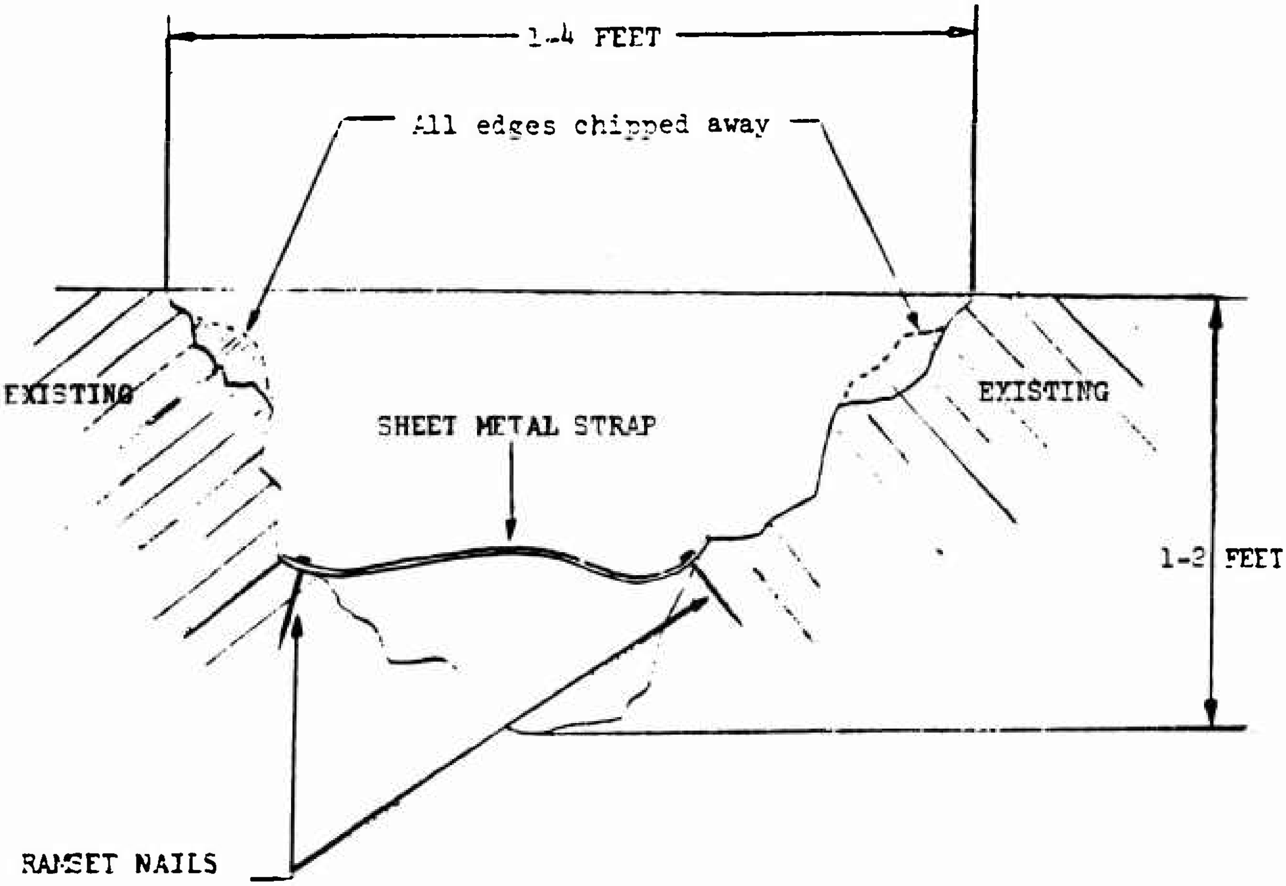

Figure A1. Recommended spall repair using silikal and reinforcement

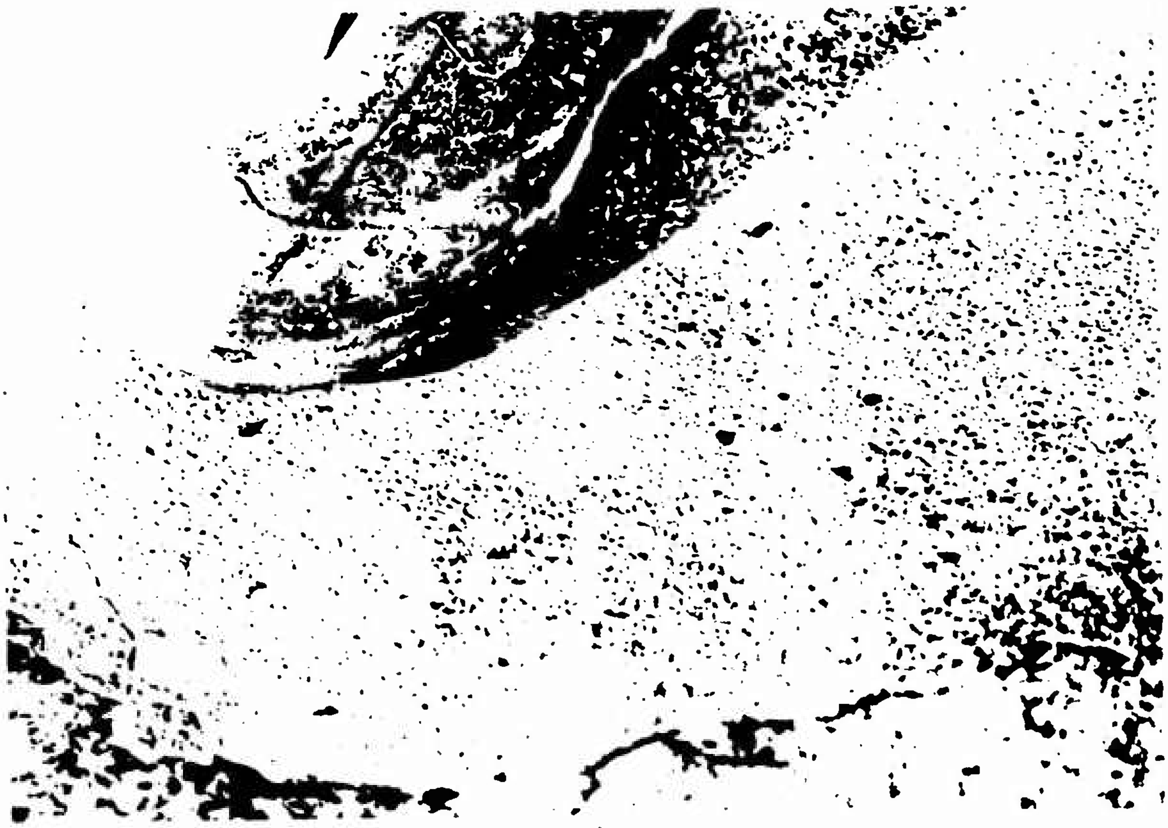

Photo A1. Cracking of edges

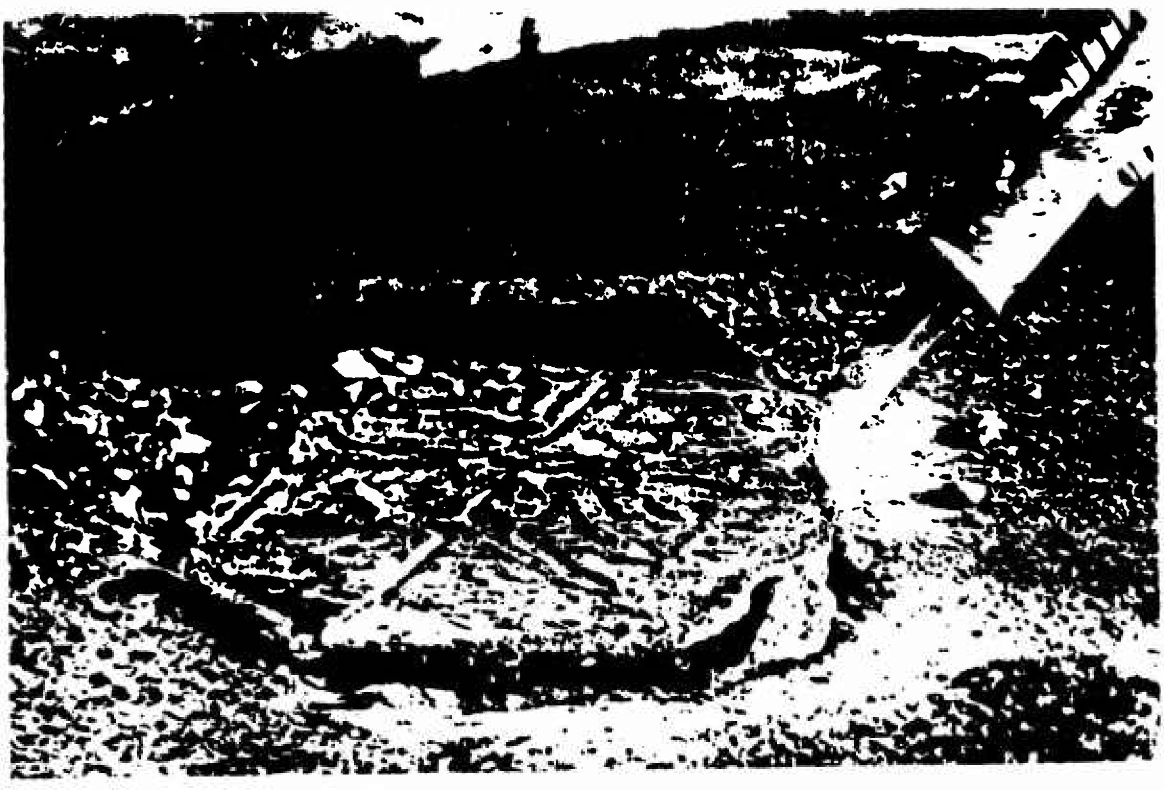

Photo A2. Spalling of repair